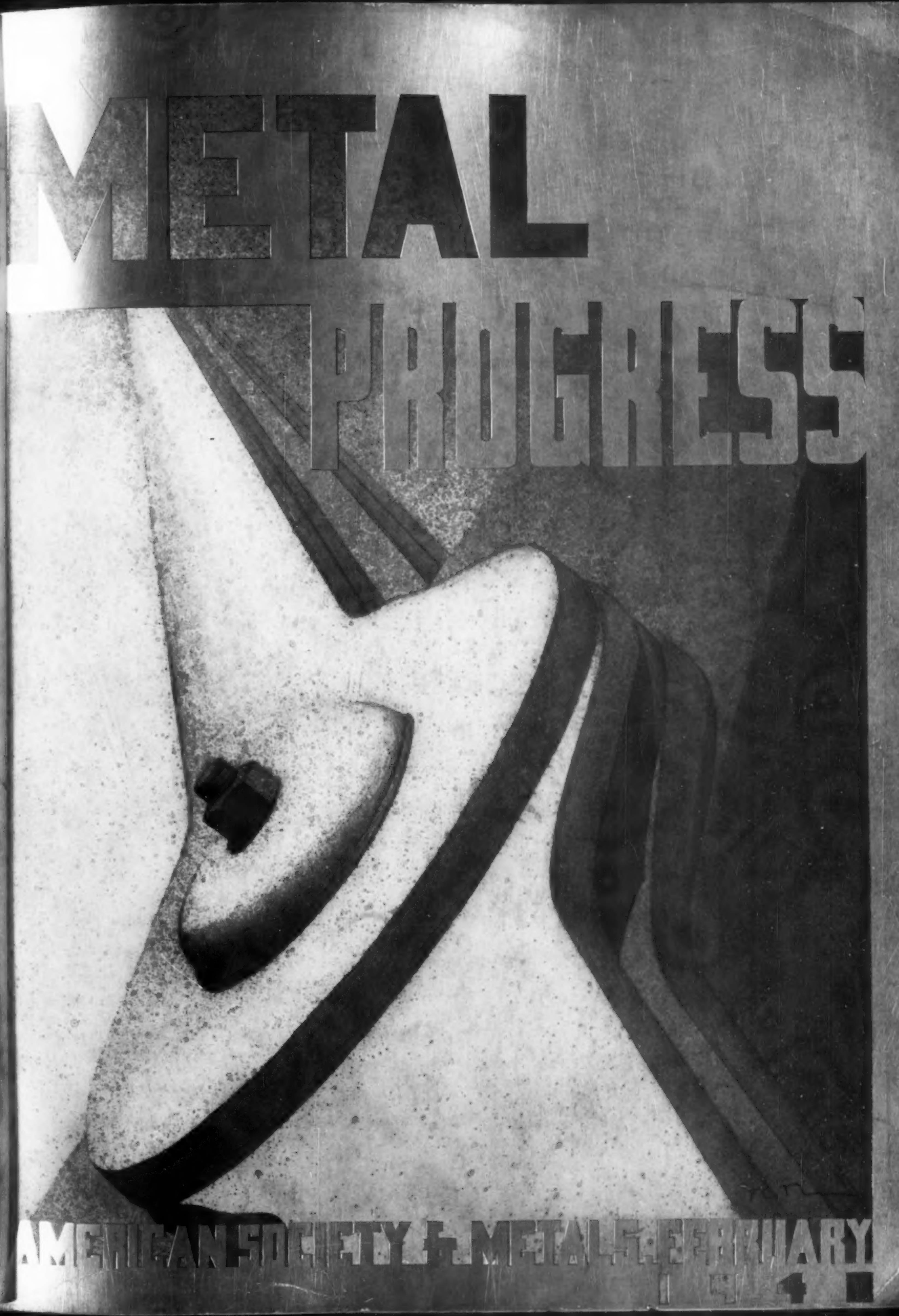
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METAL PROGRESS

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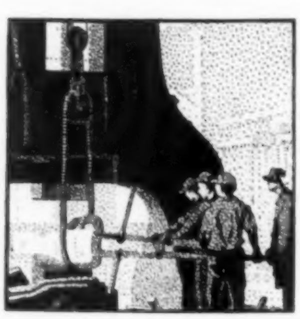
Cover is a wash drawing of eyebars in a big bridge by F. Charles Thum



Few fundamental changes have been made in the operation of tinning since the mechanical handling of the sheet by rolls was suggested. Molten tin is kept at constant temperature by immersion heaters near the entrance. Some interesting facts are given about can making

Tin Plate in the Canning Industry

THE CANNING INDUSTRY is an extremely important consumer of tin plate. This means that there is a surprisingly close connection between the production of canned goods and the production of tin and even steel. It may seem strange at first thought that tin miners in distant Malaya and producers of steel near Pittsburgh or Chicago may be honestly concerned over floods, untimely frosts, or a drought in the Middle West. Aside from humanitarian considerations, they know that any weather that would seriously curtail canning in these regions is going to affect the sale of their products.

Importance of this relationship is seen from the following:

1. Nearly all of the tin plate consumed in this country is used in making tin cans and for closures for glass and paper containers. In recent years fully 60% of the tin plate has been used in the marketing of foods produced by the canning industry — that is to say in the manufacture of about 11 billion "packer's" cans. Containers for cosmetics, petroleum products, paints, and the like run to more than 5 billion cans in the "general line".

2. The U.S.A. normally consumes about 45% of the world's production of tin, of which about half goes into the manufacture of tin plate. Some of this is exported, but an average of close to 90% of our tin plate production is consumed here.

3. U.S. tin plate production has been steadily increasing in tonnage; in 1937 — a "good" year, much like 1939 — it amounted to over 2½ million short tons. Since tin plate is 98½% steel, this is an appreciable factor in the steel industry, particularly since the domestic demand for tin plate is relatively steady (in sharp contrast to the demand for most other steel products).

Tin plate was a well developed commercial product when Nicholas Appert first made his historic experiments in preserving foods early in the 19th century. The sheets to be tinned were then of wrought iron refined with charcoal, but at least they did not have to be pounded out by hand, as was the case a century earlier. The rolled sheets were coated with hot tin by dipping them into a pot of melted metal, quite similar to the present processes except that very little machinery was used and the tin coating was much thicker than at present. (The trade still uses the term "charcoal plate" to mean, not the historic fact that charcoal wrought iron is the base metal, but the extra heavy coatings of tin.)

Since the start of the canning industry, many technical developments have evolved a better and cheaper tin plate. However, it is significant that tin plate was immediately adopted as the best material for commercially packing foods in hermetically sealed containers, and has held that position throughout the

By Bruce W. Gonser
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Columbus, Ohio

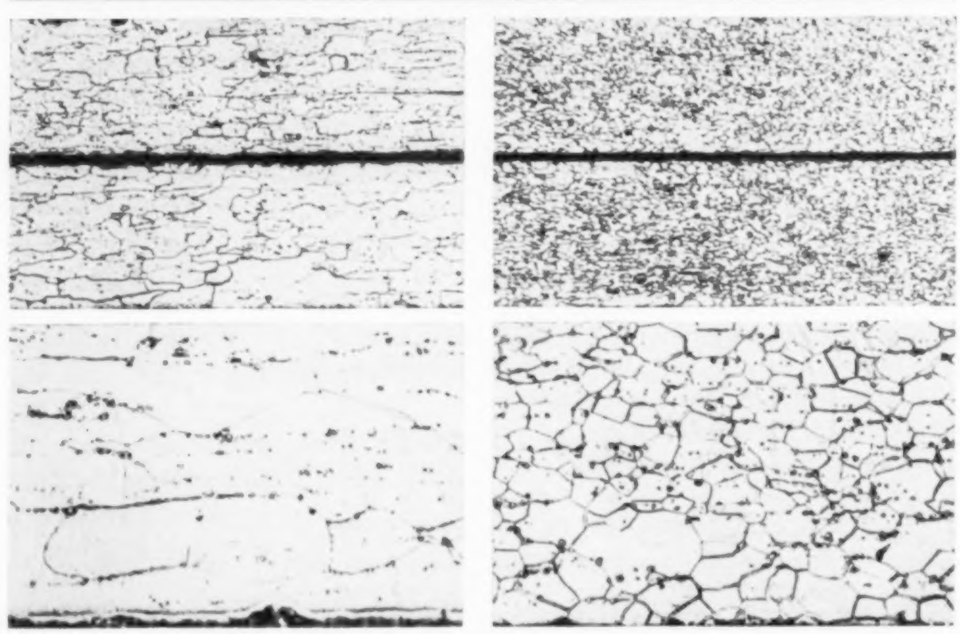
past 130 years. Perhaps the most important series of changes has been in the steel industry where the well known advancements in mechanization, the huge volume of production, and metallurgical developments of the past century have evolved uniform, high quality steel sheets at a remarkably low cost. Likewise, the tinning of these sheets has been so mechanized and controlled that a uniform, satisfactory product now requires very little direct labor.

From the viewpoint of the canner, it is in the manufacture of the cans that the most obvious improvements have taken place. The handmade cans of a century ago, with all seams soldered and a filler hole in the top which was closed by a soldered disk after packing, seem very crude indeed compared to the present automatic production of 300 cans per minute. This was a gradual evolution, of course. First the hand methods, good for three cans an hour, were aided by better forming and soldering tools; then ends were stamped from tin plate by machine rather than being cut manually. Soldering of can ends by rolling the inclined cans over a solder bath was evolved. Finally, the lock seamer and means for automatic soldering over a solder roll were invented. By 1885 an entirely automatic line for making cans was in operation in Baltimore. With the development of the open top, "sanitary" can about 40 years ago, wherein the entire can end is seamed in place with a gas-tight gasket substituting for solder, came the modern tin can. Use of various enamel or "lacquer" linings broadened the utility of the product.

Improvements to increase production and make all operations automatic reduced the cost per unit. This evolution has been a typical American mass production development; at present fully half of the world's canned goods is produced in the United States, and our can making machinery is found in most important foreign plants.

Although the canning industry, and with it the consumption of tin plate, gradually rose to great importance in the 19th century practically no tin plate was produced in this country until 1891. Wales was then the center of the world's industry, and it was said that no one but a Welshman could acquire the art. Once established here, however, the growth was rapid, and by 1911 imports had practically ceased. Exports became exceedingly important during 1915 to 1920, and have fluctuated between 50,000 and 350,000 tons per year since that time. The value of exported tin plate in 1937 amounted to about $38,000,000, far more than for any other exported finished iron or steel product.

The basic material for making containers for the canning industry is low carbon, annealed sheet steel. This is rolled as thin as practical to give requisite strength — normally to 31 or 32 g. (about 0.010 in.). Since this material must take severe punishment in seaming the cans, ductility in all directions is of great importance. Within recent years, also, it has been recognized that composition of the steel has an important bearing on the resistance of the tin plate to corrosion in various food materials. Therefore more care is needed in making steel for tin plate than most metallurgists realize, not only as to its dimensional tolerances and surface conditions, but also as to its grain size and chemical composition.

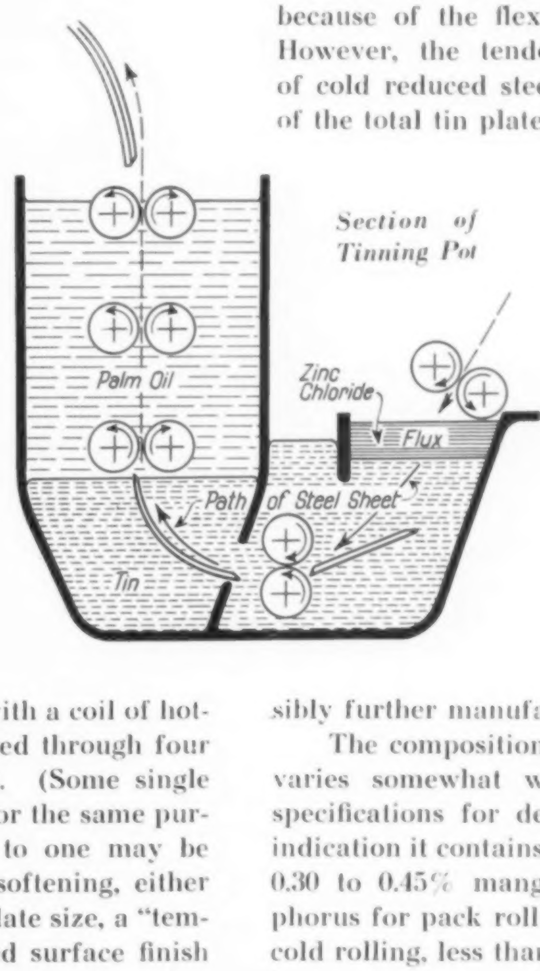


Hot Mill Tin Plate — *Cold Reduced Tin Plate*

Micrographs of Tin Plate Cross Sections, Etched With 5% Nital. Two sheets at 100 dia., above, and part of one sheet at 500 dia., below. (American Can Co.)

The manufacturer of tin plate has profited immensely from the development of heavier sheet steel for the automobile fenders and bodies; through most of the steel making and rolling the same procedures are involved. Among the various improvements, the continuous cold reduction to strip is of most fundamental importance to the canning industry and deserves particular attention.

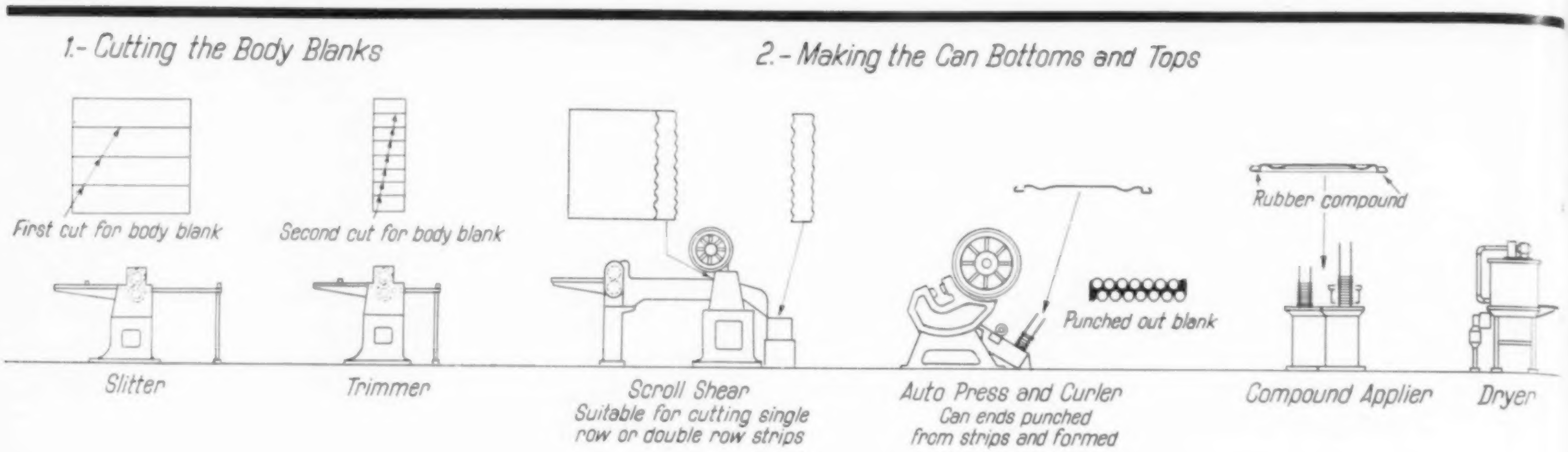
Until the last 10 or 12 years steel sheet for tin plate was "pack rolled". Sheet bars about 8 in. wide, 30 in. long and 0.5 in. thick were rolled hot through 2-high or 3-high rolls (both crosswise and lengthwise). By properly matching two sheets, "doubling" as they were rolled thinner, and eventually "redoubling" into a pack of eight, with necessary reheating, the steel was at last rolled down to tin plate thickness. This involved a great deal of arduous physical labor. Limitations were also set upon the metal composition as the presence of some metalloids, particularly phosphorus, was desired to keep the hot sheets from sticking together.



With the rapid adoption of continuous cold rolling of steel into strip during the past decade more and more tin plate has been made in continuous mills. These start with a coil of hot-rolled steel strip, which is passed through four or five huge mills, set tandem. (Some single stand reversing mills are used for the same purpose.) A reduction of seven to one may be effected. After annealing for softening, either before or after shearing to tin plate size, a "temper pass" is given for improved surface finish and to give requisite stiffness for forming smoothly. A 20x28 in. finished plate is a common size.

There was some controversy over the relative merits of pack rolled and cold reduced steel for tin plate. It was soon recognized that tin plate from the cold reduced strip was much more ductile. Manufacturers of screw caps, closures, and stamped cans, where ductility is at a premium, greeted the new material as the greatest advancement for can making since openhearth steel superseded bessemer. Tests on corrosion resistance of the tinned plate to certain food products also showed marked advantages in favor of the cold reduced material. The grain size of the cold reduced tin plate is generally more uniform and equi-axed, (as shown by the micrographs on page 136). Improvements were made in the pack rolling of tin plate, under stress of this competition, and the original differences are probably not now as marked. In fact tin mills using the pack rolling method have been modernized by adding automatic conveyors, automatic furnaces, mechanical feeders and catcher tables and the installation of 3-high stands of rolls. They are particularly efficient for handling small orders because of the flexibility of their operations. However, the tendency is strongly in favor of cold reduced steel for tin plate. Over half of the total tin plate producing capacity is now in cold rolling mills, and over three fourths of current tin plate production comes from cold reduced plate. The importance of this to the can maker, and indirectly to the canner, is not only that a more desirable raw material has been made available but that tinned plate may soon be made in the form of strip rather than as individual sheets, with possibly further manufacturing economies.

The composition of steel used for tin plate varies somewhat with plant conditions and specifications for definite uses. As a general indication it contains from 0.05 to 0.10% carbon, 0.30 to 0.45% manganese, about 0.08% phosphorus for pack rolling or less than 0.015% for cold rolling, less than 0.010% silicon if the steel is rimming steel, and from 0.03 to 0.05% sulphur. Killed or semi-killed steel is still largely used for the production of pack rolled sheet, but the tendency, especially in the continuous mills, is in favor of rimming steel, which is considered cleaner. The sheet also contains varying amounts of metallic alloys from the scrap used as raw material in the openhearth furnace. Since single impurities in steel may have a very marked effect on inhibiting or promoting corrosion in containers used for packing foods, the tendency is to "tailor" the steel to suit the



use. Thus metalloids, such as phosphorus and silicon, may be present in tin plate used for packing one food but must be rigidly excluded from containers for another product.

Manufacture of Tin Plate

Freshly pickled, clean sheet steel is tinned, or converted into tin plate, by the time honored method of immersion in a bath of molten tin under carefully regulated conditions. The cross section of a tinning pot is sketched on page 137; sheets are fed into the rolls which carry it down through the tin and up out through the palm oil. Each sheet is then inspected (both sides) by skilled girls, sorted, weighed and packed for shipment. Automatic weighing or sorting machines are now available and a few automatic inspection devices have been patented.

The thickness of the tin coating is ordinarily less than a ten thousandth of an inch on each side. In the parlance of the trade a "base box" consists of 112 sheets, 14x20 in. Common designations, average amounts of tin per base box, and computed thicknesses of tin coating (each side) are as follows:

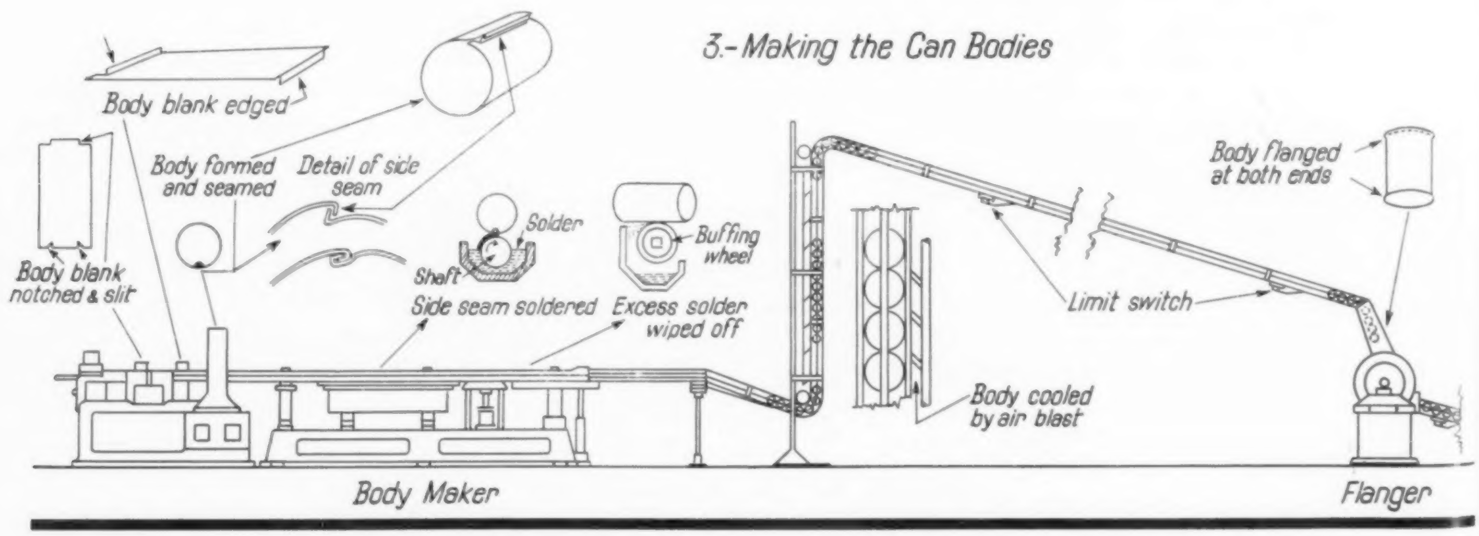
Designation	Tin, per Base Box; Average	Thickness of Average Coating	Minimum*
Standard coke plate	1.35 lb.	0.00008 in.	..
Best coke plate	1.50	0.00009	1.19
Kanner's special	1.65	0.000105	1.40
Charcoal 1 A	2.10	0.00014	1.80
Charcoal 2 A	3.00	0.0002	2.30
Premier	7.0	0.00042	4.90

*Federal Specification QQ-I-706.

The above average figures are approximations, since the regular output of standard coke plate may vary from 1.1 up to 1.5 lb. of tin per base box. Also the coating is not uniform.

Over 99% of the tin plate made is coke plate, of which by far the greatest amount is standard. Charcoal plate is used to some extent in making tinned equipment for the canning industry but not for many containers.

Tin plate is made under strict technical control; it is tested for thickness of coating, uniformity, and mechanical properties, particularly ductility. The tin content may be determined by complete chemical analysis or by



Steps in the Manufacture of Sanitary (Open-Top) Cans for Packing Foodstuffs. (Courtesy U. S. Steel News)

known quick methods whereby the coating only is dissolved and loss in weight measured, or by a magnetic method. It is quite possible, also, to remove only the pure tin coating and leave the inner tin-iron alloy layer. Aside from the usual tensile, superficial hardness and Olsen or Erichsen cup tests, a bend test has been developed by C. C. WILLETS (see METAL PROGRESS for September 1936) which is excellent for determining behavior in can making. In some plants the porosity of tin plate is measured by the time in hours to produce 5 cc. of hydrogen when a stamped sample is immersed in warm dilute hydrochloric acid.

Many attempts have been made to eliminate porosity, that is, the pinholes always present to some extent in commercial tin plate. None have been successful for practical application. Even though no pinholes may appear on the flat sheet, the base metal is usually exposed at a few points after drastic bending, as in seaming the cans. This is true of electrodeposited as well as of hot dipped plate. In reality the elimination of all pinholes is not as necessary as commonly assumed. Under the conditions existing in nearly all properly processed foods there is no serious localized corrosive attack at these points.

As to our source of tin: All is imported except for a small recovery from the de-tinning of scrap. Most of it comes from placer mining in Malaya and is known as "Straits tin", one of the best brands available. World resources are by no means inexhaustible, but there need be no immediate fear of a shortage. As an aid to users and to disseminate information pertaining to tin, the producing countries have cooperated to establish the International Tin Research and Development Council; its many technical publications are free, and to it credit should be given for the present article, a by-product of a comprehensive study of "Tin Plate and Tin Cans in the United States".

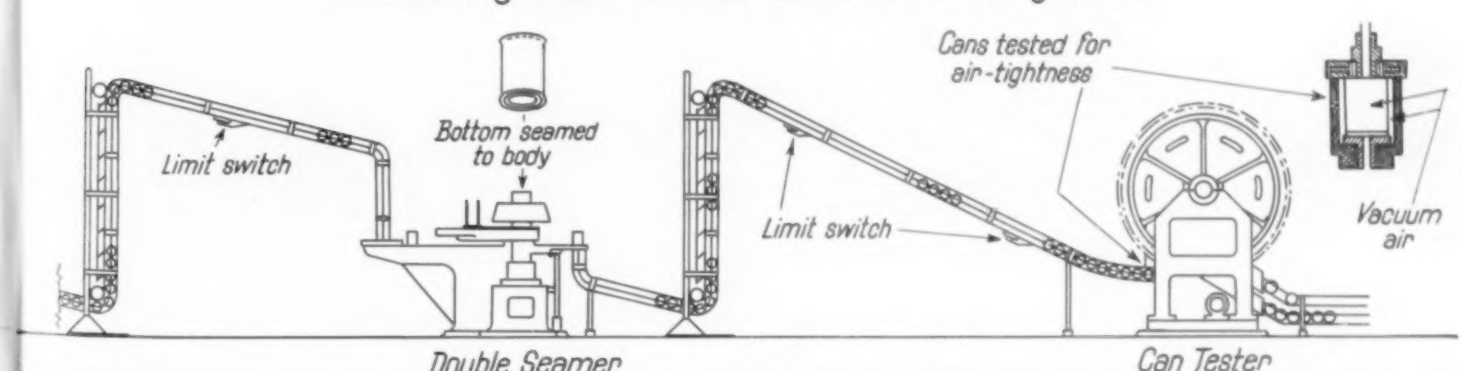
Although tin is a relatively expensive metal, averaging about 50¢ per lb. in recent years, the coating on tin plate is so thin that a little goes a long way. Contrary to the usual assumption that the cost of tin plate, and indirectly of tin cans, is largely governed by the price of tin, the actual cost of the tin is only about 15% of the sales price of the tin plate. Figured in another way, the $1\frac{1}{4}$-pt. can, called a No. 2 can, is made of about 70 sq.in. of sheet, and requires 0.003 lb. of tin in standard coke plate, costing 0.15¢ with tin at 50¢ a lb.

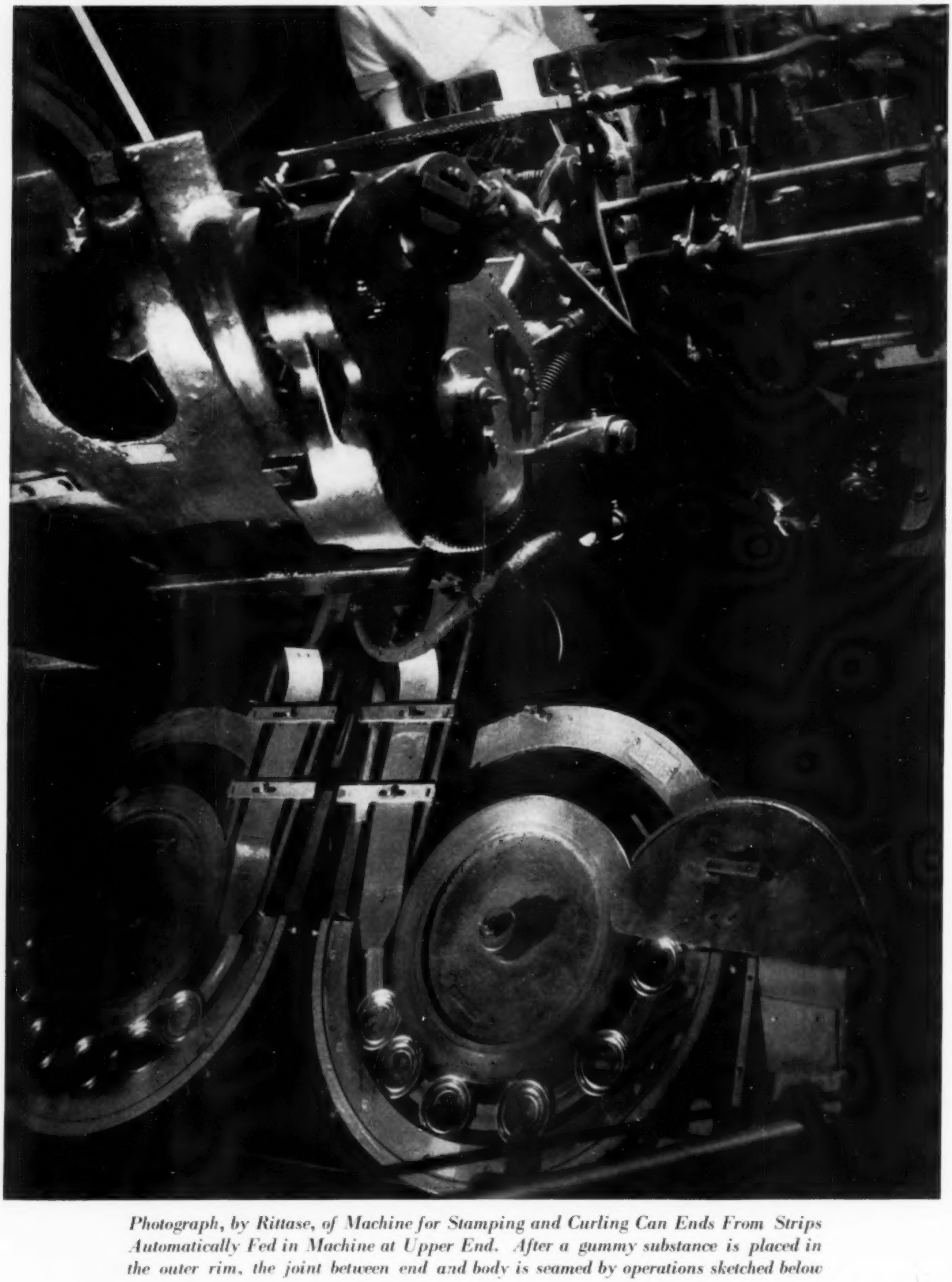
Manufacture of Tin Cans

General steps in making packers' cans are shown in the diagrams on these two pages, reproduced by courtesy of *U.S. Steel News*. Of the many auxiliary operations, not shown, the most important are applying enamel and lithographing the sheets before cutting and forming. Cans are made in one of these lines at the astounding rate of 300 per min., yet such uniform conditions are maintained and inspection is so rigid that several companies guarantee 998 out of 1000 cans not to fail in use.

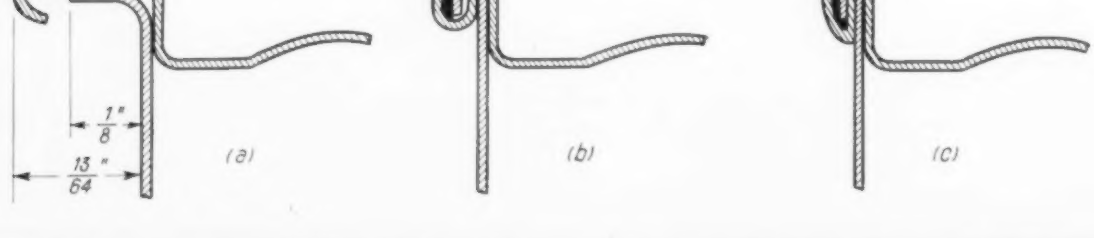
After the body blanks are cut and stacked, they are fed one by one into the "body maker". First, notches are cut at the corners at one end (to avoid bunching the metal where side seam is crimped with the ends) and the other end slit a short distance back. Then the ends are bent sharply back in opposite directions so they hook together when the body is curled into a cylinder. This seam is then pressed down tightly; a little flux is applied to its outside and, as the cylinder

4.-Attaching Bottoms to Bodies and Air-Testing Cans





Photograph, by Rittase, of Machine for Stamping and Curling Can Ends From Strips Automatically Fed in Machine at Upper End. After a gummy substance is placed in the outer rim, the joint between end and body is seamed by operations sketched below



passes along over a horn, the seam — now at the bottom — is wiped by a moving roll which is partly submerged in a bath of solder, carrying enough up to the can to seal the seam. Excess solder is then brushed off, the bodies cooled by air blast en route to a machine that flanges both ends outward.

Sealing of tops without the use of solder requires a gasket made from a gummy compound usually based on a water emulsion of latex. This liquid is sprayed into the outer rim of a properly formed lid, and then dried so a gasket of resilient material remains. When the cover is curled over and the seam locked, this forms an effective seal. (The same materials and methods are used by the canners to close the can after packing.) Final testing for tightness is done on a wheel where each can is placed in a pocket, the open end pressed against a rubber pad and compressed air admitted at about 10 lb. pressure. Any leak will operate a trip which throws aside the offending can.

The manufacture of tin cans is largely in the hands of a few companies although their plants are scattered widely; The Continental Can Co., for example, has 50 plants in the United States, Canada and Cuba. American Can Co. is even larger in number of plants and volume of production. Plenty of healthful competition is presented by about 40 other companies making cans for sale. Numbers of paint and petroleum companies also manufacture for their own use.

From the standpoint of the canning industry it is very fortunate that there are a few large can manufacturers. Not only do the economies of mass production result in a low priced container but such companies are large enough to be able to afford modern active research departments which have aided immeasurably in advancing the canning industry and in furnishing the best container available for the use desired. By actually packing a given product in containers made from tin plate of various base compositions, for example, and observing the action under accelerated corrosion conditions (such as holding at an elevated temperature for months), some of the can companies are able to specify closely the type of tin plate needed for packing a given product. These research departments are also largely responsible for developing new types of containers as well as stronger containers.

Canning seasons are frequently short in any one vicinity, hence there is a strong seasonal demand for containers. Fortunately, the variety of fruits, vegetables, and other foods is so great that these seasons overlap and leave remarkably few idle periods. This is a great aid in holding the production of cans and of tin plate fairly steady through most of the year, since cans are too bulky to store in great quantities. Plants of sufficient size to make a variety of sizes and shapes of cans for both canners and general non-food containers have an advantage in maintaining an economical balance in operation.

Although there have been few changes for many years in the manufacture of packers' cans, other than to speed production and perfect the automatic machinery, there has been a strong trend toward enamel linings, and to lithograph the exteriors. This has required better non-metallic coatings that will withstand not only any reaction with the contents, but the drastic forming operations without chipping or cracking. Fortunately, clean, dry tin plate is admirably adapted for such coatings.

Growth in the use of lithographing is illustrated more clearly by considering the 1937 production of 800,000,000 lithographed beer cans, than by referring to any one group of packers' cans. There are possibilities in making a more attractive can by lithographing than by using a paper label; this may overcome the lower cost of the latter. All lithographing and coating is done on the flat sheet before subdivision and forming, of course.

Cans are usually lined with an enamel to prevent colored fruits and vegetables from fading, or to prevent dark iron sulphide stains, where foods containing sulphur come into contact with exposed iron at pinholes in the coating. In place of lining cans to prevent acid attack on the tin plate, as commonly considered necessary for these products, many strongly acid fruits, such as grapefruit, must be packed in unlined cans. It is seldom that the tin coating, which protects the underlying iron, need be protected in turn from attack; rather the lining is usually to protect the color, appearance or flavor of the contents.

Future Possibilities

In spite of constant research on all kinds of materials for making cans, tin plate containers are still regarded as the best for the canning industry. Interesting tests have been made with non-metallic or molded *(Cont. on page 196)*

President, American Society for Metals

James Presley Gill

Our Biographical Dictionary

In the town of Latrobe, out so far on the eastern edge of the Pittsburgh industrial area that it is really in the foothills of the Appalachian mountains, are located three plants making high grade steel. Two of them are competitors in the toolsteel business. And on a round knoll above the town may be found two houses, one belonging to the vice-president of one of these competing concerns, Latrobe Electric Steel Co., and the other to the chief metallurgist of the second: Vanadium-Alloys Steel Co. A stone wall separates the two properties, but it is little more than a wind-break, for an inviting gate, open wide, leads a path from one house to another.

No better symbol could be chosen for the friendly spirit which animates Jim Gill, president of the American Society for Metals. Chief metallurgist for Vanadium-Alloys Steel Co. and its two subsidiaries, he is chief technical advisor to the management, first line of reserves to the salesmen in giving each customer his special requirements, leader of a research department that has published as much about toolsteels as its competitors combined, mentor and friend of young technicians in the plant. . . . . But why go on? Most ASMembers have met him at one time or another, for since the organization of the Society he has given at least 150 addresses before its various Chapters.

James Presley Gill was born in Montgomery City, Mo., on Jan. 21, 1895. Eventually he found himself graduating as a Bachelor of Science in Metallurgy from the Missouri School of Mines and Metallurgy, and in the last summer of the World War in the pioneering electrolytic zinc refinery of the Anaconda Copper Mining Co. at Great Falls, Montana, with Russel Caples, a fellow alumnus (now general superintendent of the Great Falls Reduction Dept.). But Gill didn't like what he calls "wet and sloppy chemistry", so he was soon back at Rolla, teaching while acquiring a Master of Science. Seeking a broader viewpoint in furnace metallurgy and heat treatment, he entered Columbia School of Mines in the fall of 1919, headed for a Ph.D. and a Rhodes scholarship. Both of these aims were abandoned, on advice of the late Prof. William Campbell, to respond to an advertisement for an assistant to A. F. MacFarland, metallurgist of the ten year old Vanadium-Alloys Steel Co. in Latrobe. Within a few months MacFarland was in another position, and Gill at the age of 24 had to sink or swim all by himself in the uncharted seas of toolsteel metallurgy.

Swim he did, by virtue of a dependence, then unique, on scientific tests rather than rule-of-thumb tradition. Small wonder that he is an enthusiastic supporter of those technical societies that kept him abreast of latest developments and gave him an opportunity to discuss his problems with fellow metallurgists. He was encouraged in this by Roy C. McKenna, president of the firm, who held a firm belief in the future and value of metallurgical science as applied to the toolsteel industry and who also was an early supporter of technical societies, particularly the American Society for Steel Treating. Depending at first on the most modest testing equipment, the facilities for investigation have been expanded into a well-organized, adequately implemented research department from which have come about 40 technical papers, chiefly in the realm of toolsteels and special steels.

Jim Gill was a charter member of the Pittsburgh Chapter, and was its chairman in 1926-27. He was chosen to present the first series of special lectures to be given at the annual convention (1934) and his notes were later expanded into the book entitled "Tool Steels". He delivered the 1936 Campbell Memorial Lecture on "High Speed Steel, Carbide Segregate and Grain Size". Likewise he early associated himself with the Metals Handbook, serving continuously on various subcommittees and becoming chairman of the Handbook Committee which published the monumental 1939 edition, giving place to Professor Dowdell when elected trustee of the Society. To such an enthusiastic and faithful member the presidency of the American Society for Metals is a fitting culmination.

Another historical note: In 1921 the trustees of the newly merged American Society for

Steel Treating decided that a gold and a silver medal should be given to those who had presented the best two papers during the year. These medals were awarded at the Detroit convention in 1922; the gold medal to EMIL J. JANITZKY for his paper on "Influence of Mass in Heat Treatment", and the silver medal jointly to JAMES P. GILL and LLOYD D. BOWMAN for "their thoughtful and comprehensive paper on the 'Metallography of High Speed Steel' ". This was the only silver medal awarded, for next year the Henry Marion Howe Medal was instituted to take its place.

One might think from the above record that JIM GILL is essentially a specialist on high speed steel. This is far from true — his interests range through the whole field of toolsteel and special steels. One instance of his ability is in the conversion of the Colonial Steel Division melting department from crucible to electric. Carbon and carbon-vanadium steels of controlled grain size had always been melted in crucibles with hit or miss success from the standpoint of obtaining the "P-F characteristics" desired. His first campaign with the electric furnace rendered 90% of the heats within specification limits as to grain size and hardenability.

GILL's success, technically, is due in large measure to an ability to interpret the fundamental scientific principles in terms of a practical approach to an ideal situation. He never takes a short cut when quality is at stake. He is tolerant of other men's ideas; he can see their viewpoint — even when talking to a customer with a questionable claim.

His success, humanly, comes from this tolerance, and an abiding confidence in the ability and honesty of his younger assistants. He was married in 1922 and has two children. Once a fair tennis player, he long since found that traveling 35,000 miles a year has ruined his game. It doesn't even permit him enough practice to get out of the dub class on the golf links at Latrobe Country Club. His real recreations come from following a pack of dogs after small game and from planting and caring for the shrubs around his spacious lawn. Here may be found all those plants indigenous to the region, and some so exotic they would perish under less skillful care.

Devising a Smaller Auto Transmission

By G. L. Rothrock

Abstract of a paper for American Gear Manufacturers Asso., May 1939

CADILLAC motor cars were pioneers in the silent transmissions or gear shifts introduced eight years ago and now used on most passenger automobiles. Many manufacturing problems arose, and since little was known about the strength and durability of the helical gears their size was larger than that of their predecessors. The transmission weighed 150 lb. and was designed for 250 ft-lb. torque. As a result of detailed study of design, improved standards of accuracy due to honing and lapping of gears, the transmission on Cadillac and LaSalle cars (weighing up to 5500 lb.) now weighs only 76 lb. and is designed to transmit 300 ft-lb. torque without trouble. A brief account will now be given of three years' work that led to the present design.

Automobile transmission gears must operate quietly and without breakage, but under full load only a small percentage of this time. We know from experience that if a unit under laboratory test conditions will transmit full torque for the equivalent of 140 miles in low, 420 miles in second and 560 miles for the constant mesh gears, we will probably have no trouble with it in service.

Early tests were run in low gear with input of 250 ft-lb. torque. Minimum life permissible (corresponding to 140 miles service) was 2.6 hr. Failure in the low gear in seven tests occurred in from 5.5 to 8.2 hr. and always started in the fillet at the front end, showing definitely that the load had been highly concentrated there.

It is interesting to note that the design had provided a long tooth face to carry the load but a shorter one would have done as well. The first thing that was done was to strengthen the case by replacing a pressed sheet cover with a stiffer casting, thus preventing some distortion and movement in the alignment. Three tests then showed an improvement of 64% in gear life. Changes were then made to improve the "contact pattern" (area and position of surfaces of contact between driving and driven teeth), notably by re-lapping the teeth

to give a more generous area in bearing under light load at the rear end of the tooth. Theoretically the gears should have meshed at the center, but actually — as shown by the failures — came in contact at the front end. These changes further improved gear life by 85% and the sets ran 20 hr.

Up to this point we had used gears cut in our experimental shop and lapped on a machine of our own design. Since production gears usually show increased life, due to less distortion in heat treatment, three factory made transmissions were tested and ran 12, 14 and 20 hr. respectively. The minimum requirement of the low gear, as previously stated, is equivalent to 2.6 hr. on our test, so that we now had a minimum factor of safety ratio of 12 hr. to 2.6 hr., or 4.6 to 1.

Similar tests were made in second gear. Life was no better than in the first low gear tests, although the tooth alignment seemed to be better (as was indicated by the wear pattern on the tooth surfaces). Tooth fracture started at the acute angled front edge; to get additional strength here, ⅛ in. of material was added, and this more than doubled their life.

As the weak members of the transmission were progressively strengthened, failures began to occur in another location, this time in the clutch connection gear. Fractures were similar to those of the countershaft head gear, but they started in the fillet at the *rear* end of the tooth. The solution seemed to be to improve the alignment by strengthening the clutch gear shaft against bending, by increasing the diameter $\frac{3}{16}$ in. Two tests of 26 and 20 hr. duration then gave us an ample factor of safety over the 7-hr. minimum requirement. This transmission was used in all 1937 Cadillac and LaSalle cars with the exception of the V-16.

While a factor of safety of 4.6 to 1 (based on average time of failure to minimum life permissible) may seem to be much greater than necessary, it actually is not so excessive, as is shown by the "scatter" of our test results. For example, the life of one head gear shown was something beyond 26.5 hr., while that of another was 7.25 hr.

Since the design must be judged on the life of the poorest gear, it follows that the life of the best gear is many times as long as need be. It also follows that if we could prolong the life of the short-life gear we could safely increase the torque handled by the transmission.

The problem seemed to be to reduce the maximum stresses that were responsible for the fatigue failure of teeth, overloaded because untimely contact was made at ends or edges. For many years we have made dynamometer tests on rear axle gears, and are able to predict the gear life with greater certainty. Consistency of test results within a range of 2 to 1 was possible for several reasons: We knew that to obtain the longest life of axles, the tooth contact pattern on the spiral bevel gears must be such that it extends over nearly the whole tooth surface when under maximum load, and that a contact located toward the larger end of the tooth always resulted in earlier failure. We also knew that full tooth contact under load could only be had if the gear and pinion deflections under load were relatively small and, consequently, very definite limits were established.

However, spiral bevel gear teeth allow for slight misalignment without concentrating the load at the extreme end of the tooth. Helical gear teeth do not have this advantage of design, so that a smaller error in tooth alignment results in extreme concentration of the load at the end of the tooth.

Efforts were then devoted, quite successfully, to the problem of alignment. Analysis indicated that deflections of a gear under load may be expressed in terms of three separate displacements, but fortunately gear tip or angular displacement of the axes is the only one that gives trouble. The angular displacements were then actually measured and found to have a definite relationship to the life of the gear.

In the improvement of this transmission to be suitable for the Cadillac V-16 motor, the torque was stepped up to 300 ft-lb. and the former series of tests in low and second gear repeated, but in this case special attention was given to the tooth contacts. Only rear contacts were used — no front contacts being allowed. These varied from one half the tooth length to nearly full length, and were sketched under light load with the gears assembled in the case. Having these pictures, we were able to compare the length of contact with the resulting life of each gear. In this way, the best length of contact was determined.

The relative value of controlling this contact may be seen by two groups of low gear tests on production-built transmissions. The minimum life without contact control was 5.5 hr. whereas the minimum life with contact control was 10.7 hr., which amounts to 100% improvement. As previously stated, the minimum allowable life is 2.6 hr. so that with 10.7 hr. minimum, we have 4.4 times the minimum life. This compares favorably with our former safety factor of 4.6.

Tooth contact specifications were drawn up from these tests and have been used in production for over two years. They have been met by two steps in the manufacturing process which deserve special mention, namely shaving and lapping. Shaving not only removes tooth errors but also produces a good finish. Most of the fine corrections for helix angle are accomplished here. The lapping machine corrects heat treatment warpage; tooth contact length may be altered by changing the stroking, so that the center of the lap is either above or below the center of the stroke.

An improved method of polishing specimens to preserve inclusions was published in Jernkontorets Annaler *in 1937 by the eminent metallographer Kurt Amberg. Mr. Liedholm has prepared this version and interpretation after correspondence with author and various manufacturers*

Metallographic Grinding With Abrasives Fixed in Lead Disks

Whether suspended in a liquid or not, loose abrasives tend to erode a surface being ground or polished. The result is the enlargement of scratches from preceding coarser abrasives, as well as of existing cavities. For example, slag inclusions cause the formation of pits in three different ways: *(a)* If softer than the abrasive, the inclusions wear faster than the matrix; *(b)* if glassy, the inclusions may be crushed; *(c)* if harder than the abrasive, they tend to be pulled out.

During grinding, the harder inclusions at first stand out in relief. The edge leading in the grinding direction gathers loose abrasive, which is gradually fed out on both sides, causing "star" or "comet tail" pits — depending on whether or not the specimen is rotated during grinding. Either action will eventually dislodge the inclusion. (Large, brittle particles are often damaged during coarse grinding, and are dislodged at a later stage.)

These shortcomings in the usual methods of metallographic polishing, especially when the object is to reveal the slag inclusions, are aggravated through the use of liquids, though not eliminated by their omission. A wet paraffin grinding and polishing method was described by the author in 1928, but it was soon abandoned because of difficulties with pitting and rusting. When grinding dry, insuperable difficulties were encountered in gaging the amount of abrasive added, so as to avoid pitting. Experiments with a lead disk were equally unsuccessful.

However, these experiments led to the conviction that for high grade results the abrasive must be held in a fixed position on the lap, which must be sufficiently though not excessively hard. The efficiency of fixed abrasives declines rapidly, because the hard grains are pushed into the matrix material, are torn loose, or the interstices between the grains become filled with the products of abrasion. The abrasive binder must therefore be such as to facilitate frequent re-dressings of the abrading surface. Many attempts led to the adoption of a steel varnish, No. 2940, made by Alfort & Cronholm of Stockholm, Sweden. As used here, diluted with benzene, it dries in less than one minute — an important desideratum.

Other abrasives tried were discarded for the American Optical Co.'s brand "Wellsworth", and a fine tungsten carbide powder, whose high cost (about $10 per lb.) is more than compensated for by its great durability. The general scheme of sample preparation is as follows:

Stage 1. Coarse grinding on an emery wheel, preferably with recessed center. The Carborundum Co.'s Aloxite Brand aluminum oxide AA wheel, 60A-0-176 or Norton's 3860 KB, are recommended.

Stage 2. Lead lap carrying emery, Wellsworth

By Kurt Amberg

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302 (grain size: 100μ max.; average about 40μ, or 0.040 mm.).

Stage 3. Lead lap carrying emery, Wellsworth 303 (grain size: 50μ max.; average about 25μ).

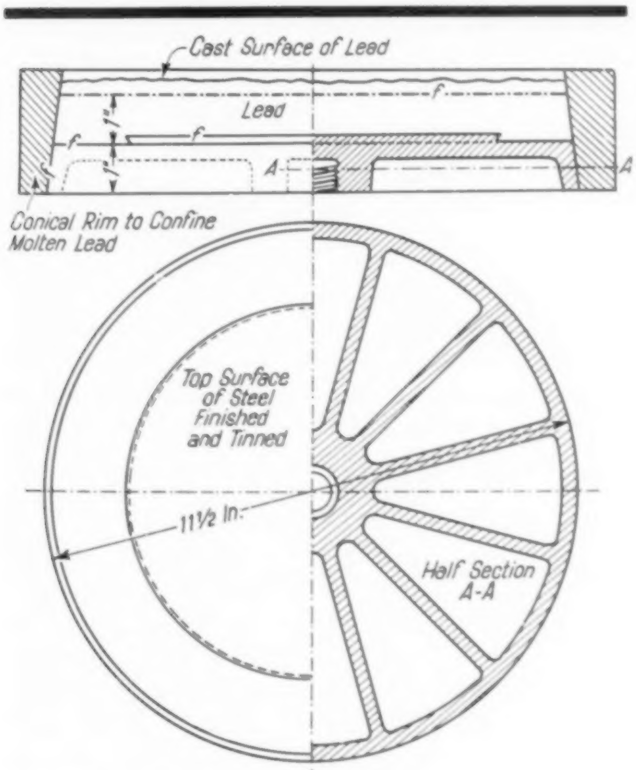
Stage 4. Lead lap carrying tungsten carbide, "Seco" brand, obtainable from The Swedish Steel Mills' representative in New York. Its grain size is less than 4μ, and inquiries have indicated that American tungsten carbide powder of this fineness is not now available.

Stage 5. Polish on cloth with alumina.

Coarser emery or Carborundum 220 can also be used directly following the emery wheel, and thereupon a coarser tungsten carbide followed by the finest powder. This practice is in use at the Metallographic Institute in Stockholm.

Preparation of Lead Laps

To prepare the laps molten lead is poured on a foundation of cast steel, and confined within a conical ring fitted around its rim to form a mold for the casting. The assembly is shown in the first sketch. The face of the steel disk should be tinned for good adherence of the lead, and, for similar reasons, should be provided with a low shoulder about two thirds of a radius from the center. Commercial lead is satisfactory; after casting, the surface is kept molten for some time with a bunsen burner to minimize pipe.



Steel Wheel Used for Foundation of Lead Lap and Method of Casting the Latter

Upon machining, the assembly should be turned on a cone center, but should never be chucked in the lathe. Finishing requires a minimum feed; burrs must be completely removed, and the surface finished quite smooth. All porosities removed, a 0.5-mm. deep spiral groove (0.02 in.) spaced 2 to 3 mm. (0.08 to 0.12 in.), extending from the periphery to the center of the lap, is cut with a threading tool. Recutting of used laps requires Widia or other carbide tools; completely remove the groove and then recut.

Lead Disk With Necessary Accessories for Preparing the Lap, Namely, Bottles of Abrasive Powder, Varnish and Benzene, and a Soft Brush

Before coating, the lap is cleaned from grease and lead chips. Coating of a 12-in. lap requires 3 to 5 g. of abrasive and 1 to 3 cc. of varnish. Abrasive is scattered over the horizontal, stationary lap, after it has been moistened with a benzene-dipped brush; the varnish is then added. A soft bristle brush about 1 in. diameter is suitable; it is kept suspended in the corked benzene bottle when not in use. Chemically pure benzene is required. The lead disk and the accessories, ready for use, are shown in the accompanying halftone. The use of a blower to dry the abrasive binder is recommended; the binder should dry in a minute or less, and it must be quite dry before being used.

Coarse Grinding—When hard laps are used, *flat* emery faces are imperative for the preliminary work, else the time required for fine grinding is inordinate. Use of a mechanically operated diamond point is recommended

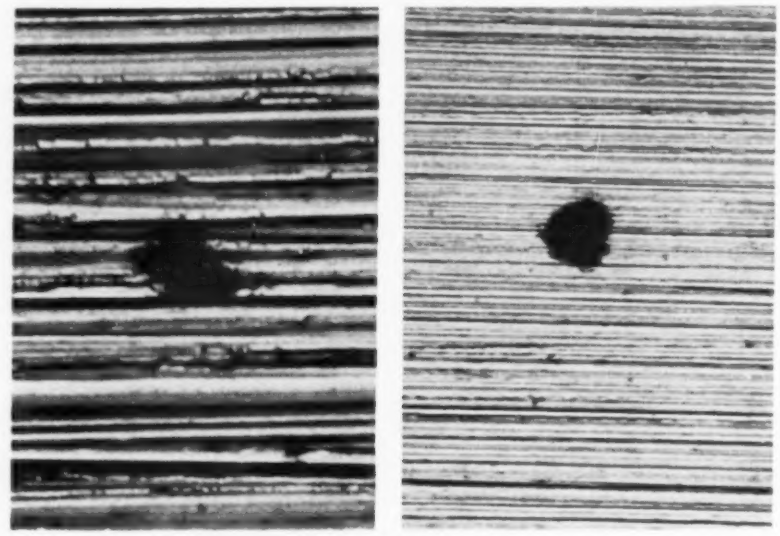
for accurately dressing the emery wheel; an arrangement for flushing with water during dressing, as well as during grinding of the specimen, is also desirable.

Fine Grinding — Hand grinding a ⅝-in. specimen on a stationary lap will wear off the abrasive coating after 50 to 100 evenly distributed strokes, whereupon the coating is renewed merely by touching up with the benzene-moistened brush. Thus the abrading surface is re-dressed, and the abraded dust simultaneously re-bound. New abrasive may be added as indicated by experience. Regardless of the grade of abrasive, each abrading surface should hold *all* grains well fixed; if they are loose, more varnish has to be added. A sticky surface indicates an excess of binding substance and the remedy is additional abrasive. Accidental denting of the soft lead lap is inconsequential if the edges of the dents are shaved smooth, below the general surface.

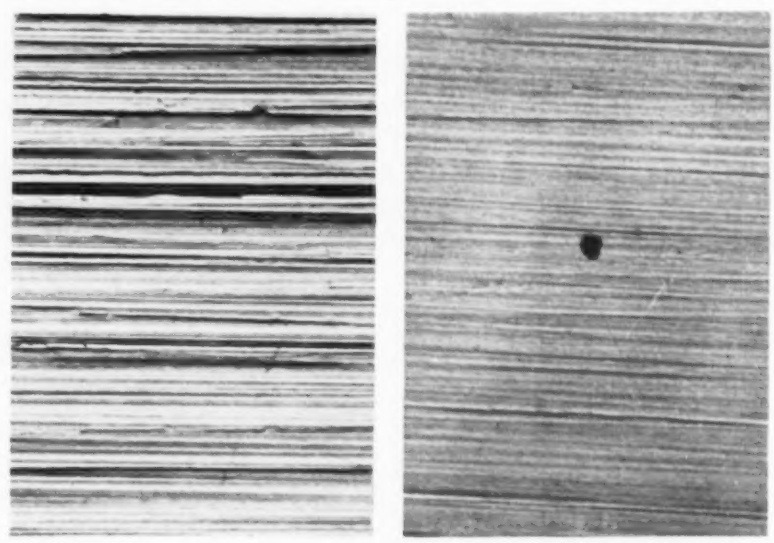
Polishing on stationary or rotating lap is optional. If a rotating lap is used, the speed should *decrease* with the abrasive grain size. Recommended speeds are given as:

Abrasive	Speed, R.P.M.
Emery, 302	300
Emery, 303	150
WC powder	50

The method has been in use since 1931, giving good results in the most difficult slag studies (even though it is far from the ultimate in perfection). Micrographs at right illustrate the startling difference in scratches between 000 paper and fine tungsten carbide powder, as well as its improved action on the inclusions.



Appearance of Scratches and of Slag Inclusions, Magnified 1000 Times, in Iron (Above) and Hardened Eutectoid Steel (Below) After Fine Grinding on 000 Emery Paper (Left) and on Lead Disk With Seco Brand Tungsten Carbide Powder (Right)



Polishing

Even a practically scratch-free, ground surface is inadequate for structural studies, since it is always attended by some cold work and heat tints on the surface which can be removed only through polishing on soft material, usually with a liquid suspension of sufficiently fine abrasive. German alumina, *Tonerde*, is used almost exclusively in Sweden for final polishing. It gives a finish comparable to that obtained with the finest re-levigated magnesium oxide or re-levigated green chromium oxide (Cr_2O_3). But the best final polishing should be done as quickly as possible, especially if wet polishing, for the resulting rust has actually been mistaken at times for structural phenomena, such as the "oxy-pearlite" reported in cast iron. A few drops of ammonium hydroxide, or 50% alcohol added to the water will correct this condition.

Edges tend to polish first on cloth polishing, resulting in their rounding. If the cloth-covered lap is given a slight convexity, about 1 mm. in 200-mm. diameter, rounding can be almost entirely eliminated. This is especially true of samples ground on lead laps, which give sharp

edges; with paper-ground samples, a convex polishing lap is useless since the edges become somewhat rounded during grinding.

Summary

In comparison with emery paper the lead lap method of fine grinding has the following advantages:

1. A very flat surface is obtained to the edge of the specimen and grinding therefore proceeds faster.
2. The abrading surface may be quickly renewed.
3. Finer abrasives may be used, and the polishing therefore requires less time.
4. The method is cheaper than the use of emery paper.

A Note on the Depth of the Disturbed Layer

Attempts were made to measure the depth of the scratches and underlying cold-worked metal. Such data are important to guide one in the study of metallurgical structure.

In these experiments, surfaces prepared up to stages 1, 2, 3, etc. were ground against the curved surface of a stationary lead cylinder, 5 in. diameter, prepared with Seco powder, so that a smooth, shallow groove was cut across the specimen in a direction perpendicular to the existing scratches. After cutting this groove and slight etching, the depth of cold work within the crystals in the direction of the scratches under consideration was measured with an optically plane glass and sodium light.

By this means the following approximate values were obtained for the depth of the cold working effect on mild steel:

Emery wheel 60A-0-176 (coarse grinding)	about 20μ
Emery 302	$<1.5\mu$
Emery 303	$<1.0\mu$
Tungsten carbide powder	$<0.7\mu$
New emery paper, 0	$<2.0\mu$
New emery paper, 000	$<1.5\mu$

Attempts to measure the depths of the scratches only gave unsatisfactory results, but their depths are estimated to be about half the corresponding figures above.

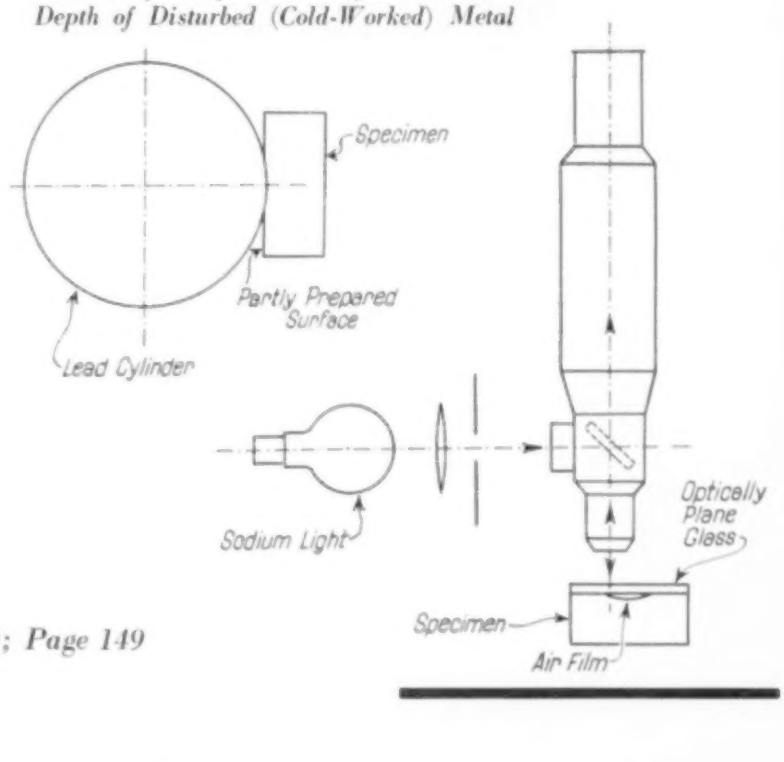
[Abstractor's Note — The accompanying sketches show the method of preparation and examination. The very small, wedge-shaped opening between under side of the cover glass and the edge of the cylindrical depression will cause interference fringes in reflected light, which may be observed under the microscope. Such interference fringes depend on the difference in the length of the path of light waves reflected at the glass-air boundary, and those reflected from the surface of the metal. The number N of light fringes will be equal to $2t\cos i \div l$, where t is the thickness of the air film, l the wave length of the light used, and i the angle of refraction which is zero for perpendicular light.]

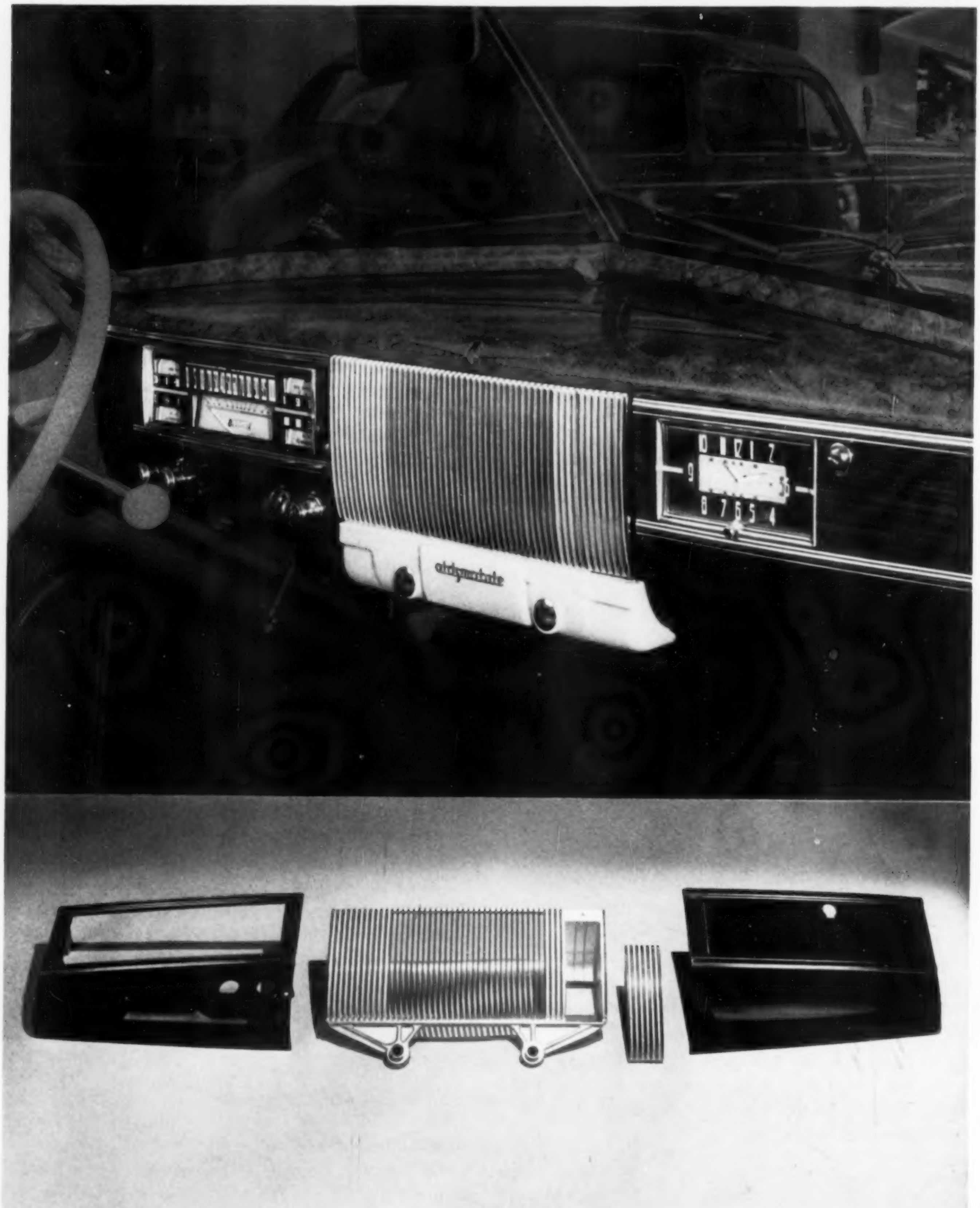
Amount of material abraded may be convenient to know when regrinding to study the depth of defects or dimensions of structure normal to the polished plane. This was estimated by optical methods (interference fringes) in a comparison with gage blocks, and by optically measuring the depth of the indentation left by superficial hardness tester. When grinding is by hand, and the lead lap re-dressed with benzene-moistened brush after the length of these strokes totals 10 meters, it is found that the depth abraded and the length of the strokes have a linear relationship, while 000 emery paper rapidly decreases in its cutting power with use. For a total length of strokes equal to 10 m., corresponding to about 45 sec. grinding time, the following results were obtained on 16-mm. dia. specimens (2 sq.cm. area) of iron and hardened 0.90% straight carbon steel.

	Iron	Steel
Emery 302	9 to 13μ	6 to 10μ
Emery 303	4 to 6μ	4 to 6μ
Seco	1.5 to 2.5μ	0.5 to 1.0μ
000 Emery paper	12 to 5μ	5 to 1μ

For hardened steel, a lead disk charged with 302 emery — when frequently re-dressed as described above — is almost twice as fast as 000 emery paper. Even at the beginning the latter abrades 5μ in 10 m. of strokes, but the rate rapidly drops to 1μ.

Method of Grinding Shallow Cylindrical Groove in Partially Prepared Specimen, and Use of Interference Fringes to Estimate Depth of Disturbed (Cold-Worked) Metal





These Four Smart Die Castings Are the Focal Point of Interior Styling on the 1940 Oldsmobile. The radio grille, with matching die cast inset forming an ash receiver, are plated; the two side panels forming the instrument frame and glove door are also plated to provide the bright integral moldings, but the remaining surfaces have a contrasting grained finish to harmonize with supporting steel sections of the panel

Of all developments in the non-ferrous industry, the production of zinc of great purity, its alloying for use in die castings, and the continued growth in size, variety and number of such castings used in industry is most notable. The result is prominent in today's automobile

Modern Die Castings for Modern Cars

AMERICAN MOTORCARS have long been, and continue to be, paramount examples of products designed for economical manufacture in large quantities. But in recent years they have also become outstanding for smart styling, without which the quantities manufactured undoubtedly would be much smaller. For today, the American public has become definitely style conscious. The products it buys from the metal working industry, as well as from many other industries, have to be aesthetically satisfying to attain maximum success — besides, of course, performing well the utility functions for which they are designed. The latter necessitates good engineering and the ability to adapt the design to economical manufacturing methods.

Since the automotive industry is a recognized leader in styling, in economical manufacture and in good engineering practice, it is natural that its lead should be followed in other branches of metal working. It is instructive, therefore, to study the reasons why it employs the type of metal product to be considered here, and then to inquire whether or not similar practice can be followed with advantage by other manufacturing industries.

Naturally, there are sound reasons why the automotive industry is the largest user of die castings. It uses this large tonnage not only because it builds a prodigious number of vehicles, but also because the number of die castings per car is large and many of the castings are of considerable size. If one goes further into the matter, however, the basic reasons include the following:

1. Die castings are economical to produce in large quantities with a moderate investment in equipment and in tooling.

2. Die castings require a minimum of machining, partly because they can be held within close dimensional limits, especially for a cast product, and the variation in the dimensions as between many thousands of castings (or as long as the die remains in use) is unusually small.

3. Die castings lend themselves to production in a wide range of shapes and with niceties in detail not readily duplicated by other means.

4. Die castings are available with surfaces so smooth that the finishing processes, such as plating and enamelling, are expedited and the cost thereof is minimized.

5. Die castings are resistant to corrosion and, in particular, are not subject to the red rust encountered in ferrous products.

6. Die castings possess good physical properties, among them toughness (high impact strength, especially in the alloys most used) superior to most of the more common low-cost cast metals.

7. Die castings can be produced in remarkably thin sections with correspondingly light weight.

8. Die castings, partly because they lend them-

By R. L. Wilcox
The New Jersey Zinc Sales Company

selves to production in complex forms, can often be produced in one piece where otherwise two or more pieces would be needed and involve extra assembly costs. Also, certain details in design, feasible in die castings, facilitate their assembly to mating parts.

This is not the complete list of advantages, but it is an imposing one and accounts for the large use of die castings in passenger automobiles. It is significant that, although the advantages listed may appear to lay special emphasis on economic factors, they have important bearing also on engineering and aesthetic factors, as will shortly be made clear. Before this is done, however, it may be well to mention the types of alloys used.

Precise data on relative consumption are lacking but it is probable that 90% of die casting tonnage going into passenger cars is in zinc alloy. The zinc alloys are not only lowest in cost per pound but also per casting. Moreover, they are easiest to cast; are likely to be the smoothest, when this is a requirement of importance; are readily plated; can usually be cast in thinnest sections; and have high impact strength as well as other good physical properties. Alloys based on aluminum and on magnesium are lighter, of course, but may cost more per casting and have lower strength, especially impact strength. Die casting costs are usually higher than for zinc alloys. Alloys based on copper and usually referred to as "brass" are the strongest of all types but also are highest in cost, most difficult to cast and involve highest die costs.

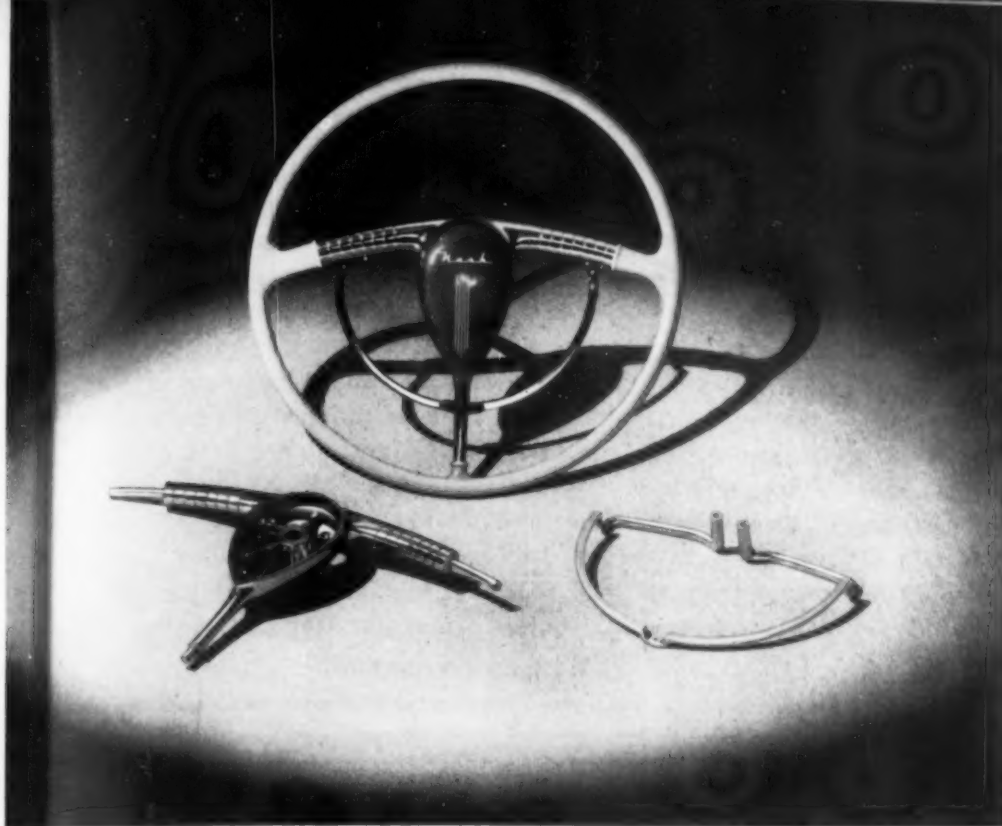
As a consequence, relatively few aluminum alloy die castings are found in passenger cars, still fewer of magnesium alloy, and copper alloy die castings in almost negligible quantities.

Die cast parts which are usually classed as "mechanical parts", and which the purchaser of the car does not often notice, were among the earliest to be used. They have continued to increase in utility and number, but now account for a smaller tonnage and number of castings than do exposed parts. The latter serve both structural and aesthetic functions, and some of them are also properly classed as mechanical parts. These hidden die castings are perhaps so well known as to require no extended comment, but they include many details of carburetors, fuel and oil pumps, filters, windshield wipers, oil seals, transmission and brake units, instruments, locks and latches, window regulators, horns. Such parts are no longer an engineering problem, as they rarely give trouble in service. They are taken for granted. Nevertheless, their present forms represent marked economies over parts of other types which might be substituted were they capable of equal economy in manufacture and equal dependability.

Many of the castings which serve structural and decorative functions are also taken for granted, to a large extent, by motor car designers because their utility has long been recognized. In other parts of this kind there is still competition, especially with stamped steel, and designers have to weigh not only the economic factors, but also the significant if less tangible matter of appearance. Considered as a group, designers outside the automotive field perhaps have more to learn about exposed and decorative parts than they have about mechanical parts. In any event, consideration of specific cases should prove profitable.

Take, for example, the modern headlamp bezel. For years, such parts have been largely stamped or spun from sheet metal, as they presented only circular surfaces. Many are still so made. But, today, the headlamp is being recessed into fenders. Style calls for smooth, well rounded contours and the elimination of projections — "streamlining", to use a much abused term. This necessitates a bezel no longer circular and one which must mate with warped surfaces at odd angles. They can be stamped, but they involve complex dies costing a great deal; variations in spring-back also make it difficult to secure good fits (in other words, to hold dimensions within close limits). Details of fastenings and mounting of glass parts also involve complexities and extra parts to be fabricated and assembled if stampings are used. Again, the stylist usually decrees a plated finish and, if this be applied on steel parts exposed to weathering, there is unsightly red rust sooner or later. Non-ferrous stampings are too costly, so the automotive designer turns, in most instances, to a die casting.

He gets such a casting in a section almost if not quite as thin as a stamped bezel. It has integral mounting parts which reduce assembly costs. Although production of the casting machine may be slower than the automatic press, the die cost is lower. Castings are accurately sized and always the same. They have exposed surfaces so smooth that little if any grinding is required; buffing usually makes it ready for plating. Such operations do not cause the piece to go out of shape or show up ripples



Nash's Steering Wheel Is Another Smartly Fashioned Interior Part in Which the Horn Ring and the Hub, With Its Steel Spoke Inserts, Merge Into a "Tear-Drop" Hub With a Neat Plastic Cap. Die castings in zinc alloy help to build a sturdy structure shaped to the queen's taste. Other adjacent parts are also die cast

or draw marks, as stampings are prone to do, and plating is easy. Naturally, with all these items in its favor, the die casting gets the call.

Right next to the headlamp bezel is the radiator grille, which is not only a larger part, but more complex and more expensive. Only a few years ago, all grilles were stamped, although a few had die cast frames. Today, the situation is reversed. Only a few stamped grilles remain and, with certain minor exceptions, in cars of the lowest price brackets where extremely large production warrants the heavy tooling cost which alone makes it possible to produce a stamped grill approximating the fine appearance of the die casting. But, among the 1940 models in the lowest price group, Ford, Studebaker-Champion, the lowest priced Hudson and Willys all have die cast grilles. In cars in the next higher price brackets, only one make retains a stamped grille.

Reasons for this shift are much the same as outlined above for headlamp bezels. In this case the saving in dollars in tooling is much greater, although perhaps the percentage saving may be about the same. Quite likely the piece cost for the stamped grille is lower but that extremely potent factor, "appearance", alone justifies this difference.

It is hard to define precisely the reasons why the die cast grille does look better, but it is partly because relatively sharp (square) corners make for trimmer lines. It is not feasible to bend sheet metal to an outside corner with radius less than the thickness of the sheet. Likewise, if the grille be stamped in one piece or even in two to four pieces, it is hard to conceal edges which have been sheared. Rolled sections are sometimes used, but then an assembly problem enters. Chevrolet has done an outstanding job in stamped grilles having major sections in one piece, but no doubt with dies costing much more than would be justified on cars built in small quantities. Some automobiles, Nash and LaSalle for example, have the main grille section die cast in one large piece. Most cars use smaller grille castings, usually two sections for the radiator grille and two, or more, additional for fender grilles.

Hudson employs a built-up die cast grille, assembled from 14 sections, but, as many are duplicate castings, die cost is probably low; it may be offset to some extent by increased assembly costs. Small units facilitate casting in light sections. The 1940 Deluxe Ford V-8 grille, cast in two moderately sized pieces, weighs only 6¾ lb. for the pair. This shows what can be done if low weight is an objective.

Until this year's models were announced, all die cast grilles had been plated and most of those used on 1940 models are so finished. This is partly because the radiator and fender grille has become the focal point in front-end styling and the highlights of a plated surface catch the eye. The "color" of a plated surface is also a pleasing contrast against any body color. This year the Ford V-8 grille (not to be confused with the Deluxe Ford) is enamelled in body color. Oldsmobile Six grilles are similarly finished, although trimmed with some plated moldings also die cast. The Ford V-8 uses enamelled headlamp bezels, but the Deluxe Ford grille and headlamp bezels are plated. This is true of most other cars. Some tail lamps and some other zinc alloy castings exposed to weathering have long been produced with enduring enamelled finishes.

Space for more than a brief reference to other external die cast parts in general use is lacking, but such parts as hood and body moldings (up to 60 in. long), hood louvres, "prow" moldings and ornaments, running board fittings, name plates, complete license lamps and direction signal fittings, exterior hardware are all being used extensively. Most of these are prominent styling items readily produced in attractive and widely varying shapes to fit any surface, and often with fasteners integral. They have much to do with the fine external appearance of the modern car.

radio grille would be likely to look "tinny", be so thin as to vibrate through resonance, and involve a large tool cost. Die castings avoid all these drawbacks. Some glove door or instrument frames are stamped, but they lack solidity and, usually, fine appearance. Consider the convenience: A glove door may be die cast in one piece with hinge parts, clock mounting and lock bosses integral if desired. The *stamped* door usually has to be made with inner and outer shells and other parts separate, each piece requiring its own dies and separate assembly.

Die cast instrument panel parts often have

Increased Eye Appeal Is Attained in 1940 Ford by Die Cast Radiator Grilles (Used for the First Time by One of the "Big Three"). The Ford Deluxe, here shown, has plated grilles weighing only 6¾ lb., and handsome nose fittings similarly cast and finished

When it comes to interiors of bodies, the die casting again shines — in more ways than one. The focal point of the interior is the instrument panel and, although the panel proper is a steel stamping, it is almost invariably replete with die cast parts, including the radio grille, instrument frame, glove door and moldings. Smart styling and economy in construction are the primary reasons for such use. A stamped

recessed surfaces with grained finish and raised moldings in contrasting plated finish, yielding the required harmony with adjacent parts but adding a unique smartness. Not a few combine enamelled and plated areas with pleasing results. Castings are often combined with small molded plastic parts and, in a few instrument panels, plastics have been substituted in fairly large size, though seldom with equally satisfac-

tory results, for the plastic lacks the strength of the die casting. Some makers who have tried plastics for large instrument panel parts have returned to die castings. Plastic moldings are weak unless they are reinforced by metal, and dimensional tolerances are more generous.

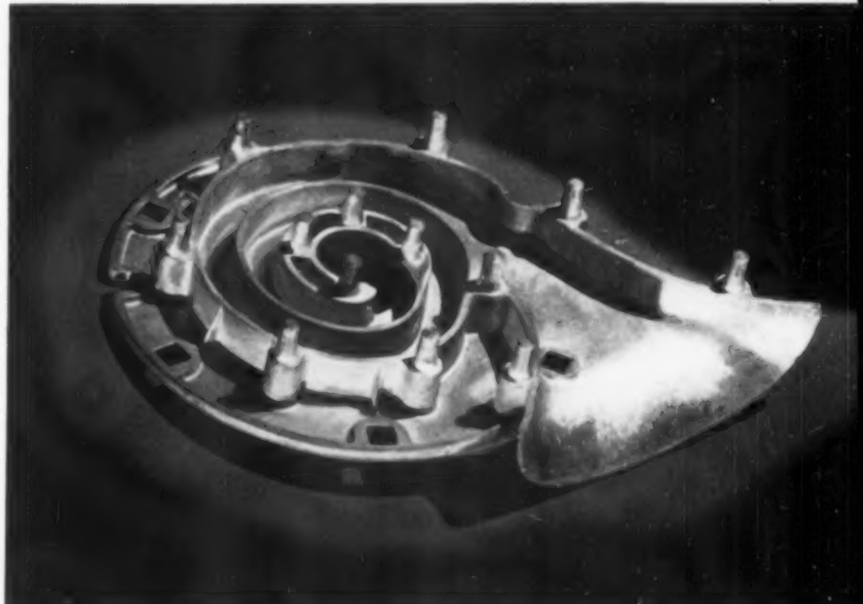
Many other die castings are used for interior fittings, including door handles and window regulator cranks and knobs (although plastic knobs are popular today because of their attractive coloring). Many cars now have several die castings on and around the steering column and these, too, enter the styling picture. Most makes use steering wheel hubs which are die cast in zinc alloy and some have cover portions around the hub also die cast. Some hubs have steel spokes cast in place and others make use of spokes of stainless steel wire inserted after casting. In both types, a steel rim is applied and is covered, as a rule, with molded plastic which, being thus reinforced, serves its purpose well. Horn rings are nearly all die cast, spokes included, as this results not only in favorable shapes, pleasing to the eye, but in a one-piece unit, avoiding assembly cost of built-up rings.

Below the steering wheel some cars use a die cast gear shifting lever or one having die cast parts, such as the housing around the inner end of the lever. Some include recesses for direction signal control. Thus, the assembly carried on the steering column often consists largely of die castings and is second only to the instrument panel as an interior styling feature. For 1940, some makers give up the flexible spoke steering wheel in favor of a more rigid type, but retain the die cast hub. Often the horn button is a molded plastic, matching the rim.

Heaters are among the important interior accessories. Some heaters have the entire housing die cast in thicknesses of 0.040 to 0.050 in. and some also have the blower and fan housing die cast, besides which several fittings are also so made.

Instances similar to those cited above could be multiplied, but it is apparent that the die casting has grown in importance in motorcar use for excellent reasons. Although conditions are not identical in other types of product manufactured in quantities, many of the requirements are so nearly parallel that the die casting presents almost the same advantages. To deny this is merely to close one's eyes to developments which have already taken place or are in process. Although all industries could profit by further study of automotive applications of die castings, it is not unlikely that some already use more die castings, *in proportion to their size*, than the automotive industry does. In fact, as the physical size of the particular product decreases, the proportion of die castings which can be used effectively is likely to increase.

It should not be concluded from this brief outline that the increased use is entirely at the expense of other types of parts, or that it is likely to crowd them out of the picture. Each class of product has its own peculiar set of advantages and the choice between them usually hinges on a variety of considerations. Where there is a chance for a difference of opinion as to the suitability of one or another, the designer should weigh the evidence on all sides and be guided accordingly. There certainly are many cases in which designs might be improved and cheapened, were the substitution of die castings given due study. Even the most experienced designer may be mistaken, especially if he takes too much for granted and fails to take note of the inherent merits of different types of parts likely to fulfill his needs most acceptably. Relative costs naturally have to be given due weight. But, as has been pointed out, better appearance, reduction in the number of parts, ease of finishing and assembly and good resistance to corrosion also are among the factors often prompting the choice of die castings. None of them should be overlooked in the final decision.



With Quality About Equal, Choice of Material for Horns Depends on Cost. How could such a part, complete even to self rivets, be more elegantly made than by die casting?

Metallurgists of scientific propensities are attempting to correlate and systematize the facts known about the arts of extrusion, wire making, sheet rolling, stamping and deep drawing. A recent series of meetings in Pittsburgh took stock of the present situation

The Cold Working of Metals

DURING the week of December 4th, 1939, the Department of Metallurgy and the Metals Research Laboratory of Carnegie Institute of Technology sponsored a series of nine lectures on the cold working of metals. The list of those presenting these lectures was indeed impressive, and it is doubtful if such a "board of experts" on this subject was ever before assembled. Following each of the lectures was a discussion period when many questions were asked by the 200-odd persons registered.

Upon introducing the clinic, ROBERT F. MEHL, head of the Department of Metallurgy and director of the Metals Research Laboratory, emphasized that it was purely an experiment, designed to be of service to the younger men in the metallurgical industries and stressing the practical engineering aspects of the selected subject. This experiment would determine whether similar conferences would be held in the future, and an analysis of the answers to a questionnaire distributed to those in attendance can be used to measure the success of the clinic.

One of the most difficult assignments was that drawn by MAXWELL GENSAMER, associate professor of metallurgy, Carnegie Institute of Technology. It fell his lot to present in the space of two short lectures the fundamentals of plastic deformation, strain hardening, preferred orientations, directional properties, and the effects thereon of certain variables, such as speed and temperature of deformation.

Starting his discussion with the conditions existing for a single crystal of a metal, Dr. GENSAMER showed that plastic deformation was accomplished by means of either or both of:

1. Slip along certain well defined crystallographic planes and in certain directions in these planes; and 2, twin formation.

Those metals having hexagonal crystal structures — the most common being zinc, magnesium and cadmium — have but one slip plane and if it were not for the fact that crystallographic "twinning" is so readily accomplished in these metals they could withstand but little cold deformation. The convenience of twin formation is twofold; not only is deformation accomplished thereby, but the new orientations of crystalline planes resulting from twinning are such as to bring slip planes into positions favorable for further deformation.

The face-centered cubic metals — aluminum, copper, gold, lead, silver, and others — are blessed with a set of four planes of easy slip and three possible slip directions in each plane. This gives rise to twelve possible slip systems in a crystal of these metals, and this is the reason why they are frequently referred to as the "ductile metals".

By Dana W. Smith
Aluminum Research Laboratories
New Kensington, Pa.

Body-centered cubic iron (ferrite) shows a complicated system of slip planes with three different families of crystallographic planes represented. The choice of slip systems during deformation is dependent on temperature and composition. For example, relatively pure iron appears to slip on {011}, {112} and {123} planes at ordinary temperatures and only the {011} planes at lower temperatures. If silicon in the ferrite is sufficiently high, slip occurs only on {011} planes regardless of temperature.

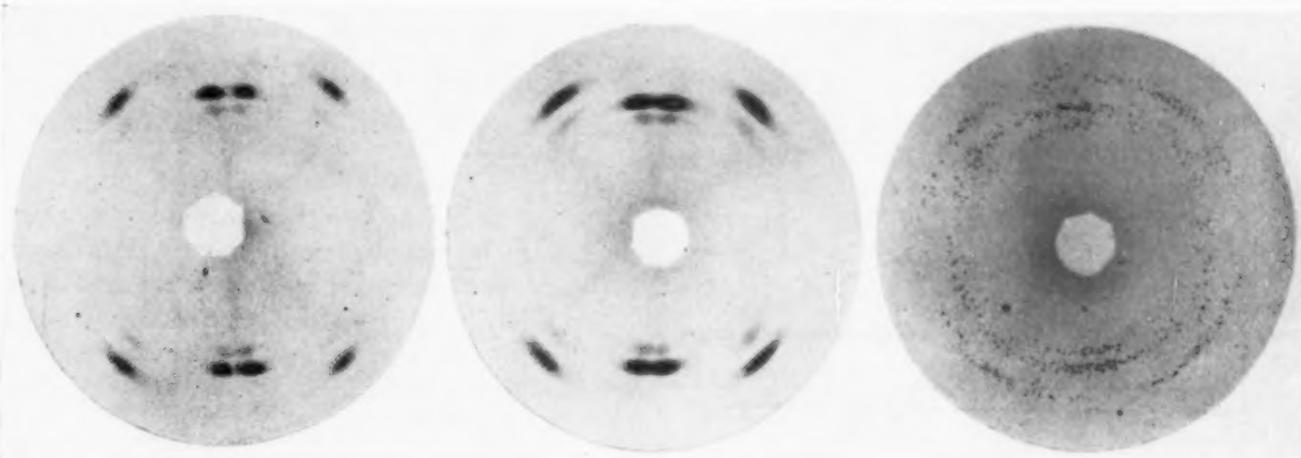
This very definite tendency of all metal crystals to deform in particular manner results in "preferred orientations" of grains during deformation. Preferred orientations are not peculiar to plastically deformed metals or alloys alone. For instance, annealing of a cold worked metal causes recrystallization which embodies re-orientation of grains and grain fragments in such a manner as to result in another type of preferred orientation, referred to as "recrystallization texture" to distinguish it from "deformation texture".

When preferred orientations exist in a fabricated item, directional properties are observed. For example, the tensile properties of sheet will exhibit variations dependent upon the direction of the longitudinal axis of the test specimen in relation to the rolling direction. Formation of "ears" along the edges of deep stampings in sheet is likewise related to preferred orientations already existing in the sheet, having originated during the plastic working or the annealing.

The lecture "Effect of Cold Work on Mechanical Properties" by Samuel L. Hoyt of Battelle Memorial Institute was delivered in the typical "Hoyt fashion". He proceeded to enlighten the attentive audience with his knowledge of the effect of cold work on the ordinary tensile properties, fatigue strength and notch sensitivity, with discourses on effects of internal and external defects and the industrial importance of strain-aging. Needless to say, Dr. Hoyt was belabored with many questions of practical nature during the discussion period. It was while answering these questions that he emphasized the impossibility of giving detailed solutions to various problems which may be raised, without careful consideration of all the variables such as composition, whether the steel was openhearth or bessemer, whether it was hot rolled or cold rolled, flat rolled or continuous rolled — to mention only a few.

George Sachs, professor of metallurgy at Case School of Applied Science, gave two excellent lectures which were consumed with interest and enthusiasm by the audience, be they research, development or production personnel. The first, on the "Flow of Metals in Forming Operations", dealt primarily with the fundamental laws of plastic flow. Building on this basis, Dr. Sachs discussed the mechanics of flow and uniformity of deformation during rod and wire drawing, deep drawing, extrusion, forging and pressing; indicating the effects of speed and temperature and the role of friction on power consumption.

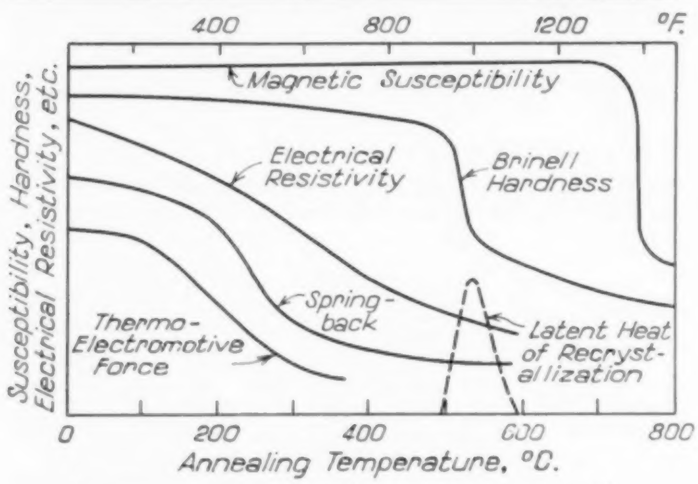
In his second lecture on "Cold Rolling", Dr. Sachs described the various modern mills



X-Ray Diffraction Photogram of Rolled Aluminum Foil — *Partially Recrystallized After 10 Min. at 500° F.* — *Completely Recrystallized After 10 Min. at 650° F.*

— two-, three- and four-high, cluster and Krause mills — pointing out their advantages and disadvantages. He discussed in considerable detail the effects of surface condition of both rolls and stock, front and back tension, and the effect of lubricants on the power consumption during rolling.

Your reporter feels entirely inadequate, in the space available, to do justice to the interesting and valuable information included in these two lectures. However, Dr. SACHS says, "I'm writing a book, soon to be published by the ." This is a bit of pre-publication information which should be welcomed by all interested in metal working. Judging by the lectures this book should be included on the *must* list.



Recovery and Recrystallization in Iron, Cold Rolled 95% and Annealed 60 Min. "Spring-back" is increase in diameter of a roll of strip after removing it from a forming mandrel

"Deep Drawing of Steel Sheet" was the subject assigned to JOSEPH WINLOCK of Budd Manufacturing Co. His talk was profusely illustrated with slides showing examples of modern deep drawings — principally auto-body panels and fenders — with many examples of "headaches", such as "beautiful worms" (stretcher-strains to some and Lüder lines to the minority), "orange peel" and "ocean waves". Mr. Winlock very logically correlated these surface imperfections with conditions existing within the sheet. "Worms" result from the sudden elongation at the yield point, characteristic of annealed steel sheet, and can be eliminated by giving the sheet light passes through a series of flattening rolls. If, after these flattening passes, the sheet is allowed to "age" for any considerable time at ordinary temperatures or for shorter times at elevated temperatures, it will recover its yield point elongation and will again suffer from "worms" after deep drawing. "Orange peel" is directly related to the grain size of the sheet. Other surface irregularities are traceable to inclusions, segregation bands and the like.

The practical aspects of "Wire, Bar and Tube Drawing" were very adequately presented by ELMER E. LEGGE of the American Steel and Wire Co. With an interesting set of slides, the "start-to-finish" processes in bar and wire drawing were shown in detail. These slides were accompanied by discussions on the heat treating, cleaning and baking prior to drawing; the effect of lubrication and surface condition of both rod and die on the quality of the finished product.

In the natural sequence of events, Dr. MEHL delivered an enlightening lecture on "Recovery and Recrystallization". Cold worked metals, upon annealing, may experience recovery, recrystallization and grain growth dependent upon the following:

1. Composition.
2. Purity.
3. Amount of cold deformation.
4. Annealing temperature.
5. Time at temperature.
6. Original grain size.

The effect of recovery is to increase electrical conductivity and decrease internal stresses with little change in other properties. On the other hand, recrystallization is accompanied by considerable decreases in hardness and strength with a corresponding increase in ductility. Furthermore, visual evidence of recrystallization is possible by means of microscopic examination, while X-ray diffraction patterns also are capable of detecting this phenomenon. Grain growth is merely a continued growth of recrystallized grains.

The following fundamental laws of recrystallization are now well recognized:

1. Recrystallization occurs at a higher temperature the smaller the degree of strain hardening.

2. Increasing time of annealing displaces recrystallization to a lower temperature.

3. The final grain size is chiefly dependent upon the degree of deformation and to a lesser degree on the annealing temperature. A further variable is the rate of heating to the annealing temperature. *(Cont. on page 178)*

MAGNESIUM ALLOYS

Compositions, Properties, and Designations of American Commercial Alloys

Compiled by H. S. Jerabek, University of Minnesota, with the help of W. H. Gross of Dow Chemical Co., and R. T. Wood of American Magnesium Corp.

Form	A.S.T.M.		Navy Bureau of Aeronautics		U.S. Army Air Corps		S.A.E. No.	Am. Mg. Corp.	Dow Chem. Co.	Composition, Per Cent Magnesium=Remainder			Condition	Tensile Strength (a)		Yield Strength (a)		Elongation in 2 In., %		Brinell Hardness	Shear Strength (a)	Endurance (b)	Uses and Characteristics
	Alloy No.	Specification No.	Alloy No.	Specification No.	Grade	Specification No.				Al	Mn	Zn		Typical	Min.	Typical	Min.	Typical	Min.				
Sand Castings	4	B80-38T	4	M-112f		57-74-1C	50	265	H	6.0	0.2	3.0	As Cast	27	24	11	10	5	4	51	17	10	General casting use.
													Cast; Soln. T. (c)	37	30	12	10	10	6	53	18	10	Sand and permanent mold castings.
													Cast; Soln. T.; Aged (d)	37	32	18	16	4	2	70	19	9	
								241		8.0	0.1		Cast; Soln. T	33	29	11	9	10	8	48	18	7.5	Sand and permanent mold castings.
							500	260	C	9.0	0.1	2.0	As Cast	23	20	14	10	1		62	18	10	Pressure tight castings.
													Cast; Soln. T. (c)	39	30	14	10	10	6	61	20	10	
													Cast; Soln. T.; Aged (d)	38	32	20	18	3	1	77	22	10	
	2	B80-38T						240	G	10.0	0.1		As Cast	21	18	12	10	2	1	53	18	8	Sand and permanent mold castings.
													Cast; Soln. T.; (c)	33	29	12	10	8	5	52	20	10	
													Cast; Soln. T.; Aged (d)	34	29	19	17	1		69	22	8	
	3	B80-38T						246	B	12.0	0.1		" " "	32	27	20	17	0.5		85	19	7	Hard castings. Pistons.
			11	M-112f				403	M		1.5		As Cast	14	12	4		5	3	33	11		Best salt water resistance.
								244		4.0	0.3		" "	24	20	9	8	6	4	44	14		Aircraft tank fittings.
Die Castings	12	B94-39T		M-369	1	11319		230	K	10.0	0.1	(f)	As Cast	30		22		1		68			Thin section die castings.
	13	B94-39T		M-369	1	11319	501	263	R	9.0	0.2	0.6	" "	33		20		3		66			General die castings.
Extruded Bars and Rods	6	B107-38T							F	4.0	0.3		As Extruded	40	37	29	25	16	12	47		14	General extrusions.
	8	B107-38T	8	M-314b(e)	1	11320(e)			J	6.5	0.2	0.7	" "	43	40	30	26	17	12	54		17	Improved strength.
	8	B107-38T	8	M-314b(e)	1	11320(e)	520	57s	J	6.5	0.2	0.7	" " ; Stretched (g)	44	40	32	26	15	12	55	20	15	Screw machine rod.
	11	B107-38T	11	M-314b	2	11320		3s	M		1.5		" "	42	32	27	20	6	3	42		10	Best salt water resistance.
	9	B107-38T						58s	O	8.5	0.2	0.5	" "	47	43	33	28	11	9	61		17	Bars of high strength.
	15	B107-38T	15	M-314b(e)	1	11320(e)	521	74s	X	3.0	0.2	3.0	" "	42	39	30	26	19	15	51		18	Heat treatable bar.
	15a	B107-38T	15a	M-314b(e)	1	11320(e)	521	74s	X				" " ; Aged	44	41	34	30	13	10	54		17	
								59s	G	10.0	0.1		" " ; Stretched	51	45	38	33	9	6	70	23	16	Highest hardness and strength.
							52	52s	Fs	2.8	0.3	1.0	" " "	40	37	30	25	17	12	50	19	12	Good ductility and impact toughness.
Extruded Structural Shapes	8	B107-38T	8	M-314b(e)	1	11320(e)	520	57s	J	6.5	0.2	0.7	As Extruded	42	38	27	23	15	10	58			Good strength and weldability.
					2	11320		3s	M		1.5		" "	35	30	23	16	6	3	42			Best salt water resistance.
	15	B107-38T	15	M-314b(e)	1	11320(e)	521	74s	X	3.0	0.2	3.0	" "	42	39	25	22	17	10	59			Heat treatable shapes.
	15a	B107-38T	15a	M-314b(e)	1	11320(e)	521	74s	X				" " ; Aged	43	40	28	25	14	8	62			
								58s	O	8.5	0.2	0.7	As Extruded	44	40	29	25	11	8	58			Improved strength.
								59s	G	10.0	0.1		" "	48	45	37	30	9	6				Highest hardness and strength.
								52s	Fs	2.8	0.3	1.0	" "	39	35	28	22	15	11				Good ductility and impact toughness.
Extruded Tubing			8	M-366a(e)	1	11318(e)		57s	J	6.5	0.2	0.7	As Extruded	40	36	19	17	9	7	55			Good strength and weldability.
			11	M-366a	2	11318		3s	M		1.5		" "	35	32	17	17	5	3	40			Best salt water resistance.
			15	M-366a(e)	1	11318(e)		74s	X	3.0	0.2	3.0	" "	40	36	19	17	9	7	55			Heat treatable tubing.
								74s	X				" " ; Aged	41	37	22	19	7	6	59			
								58s	O	8.5	0.2	0.7	" " "	42	39	29	25	5	4	60			Highest strength tubing.
								52s	Fs	2.8	0.3	1.0	As Extruded	35	32	16		11		50			Good ductility.
Press Forgings	8	B91-38T	8	M-126c(e)				57s	J	6.5	0.2	0.7	As Forged	41	38	25	22	9	6	56	21	15	General forging. Good ductility.
			11	M-126c				3s	M		1.5		" "	33	29	19	12	6	2	43			Weldable forgings.
	9	B91-38T	9	M-126c(e)		11321(e)		58s	O	8.5	0.2	0.5	" "	45	42	30	24	7	5	69	22	16	Forgings, simple design. Strong.
	15	B91-38T	15	M-126c(e)				74s	X	3.0	0.2	3.0	" "	41	38	24	20	16	9	59		17	Heat treatable forgings.
	15a	B91-38T	15a	M-126c(e)				74s	X				" " ; Aged	42	38	28	22	14	7	62		17	
Hammer Forgings	16	B91-38T						65s		3.5	0.2	(h)	As Hammer Forged	38	35	22	20	12	6	52	16	10.5	Hammer forgings.
									L	3.0	0.2	(i)	" " "	37	34	26	19	11	6	51		10.5	" "
Rolled Plate, Sheet & Strip	7	B90-38T					511		Eh	6.5	0.2		As Hard Rolled	45	39	34	28	9	3	70			Sheet with high strength.
									Ea				Annealed	39	(42 max.)	20		15	10	57			
	6	B90-38T					510	53s-H	Fh	4.0	0.3		As Hard Rolled	44	36	35	25	10	4	60			Sheet with high strength.
								53s-O	Fa				Annealed	36	(38 max.)	22		18	10	50	18	10	
	11	B90-38T	11	M-111d		11317	51	3s-H	Mh		1.5		As Hard Rolled	37	32	27	24	9	4	53			Sheet with best formability and salt water resistance.
								3s-O	Ma				Annealed	32	(35 max.)	16		15	12	44	17	8	

(a) In 1000 psi. Yield strength is the stress at which the stress-strain curve deviates 0.2 % from the modulus line.
(b) Endurance or fatigue limit for 500 million reversals of the load, in 1000 psi.
(c) Solution heat treatment: Soaking at about 630 to 810 °F. followed by air quenching.
(d) Solution treatment followed by artificial aging at about 350 °F. (precipitation hardening).
(e) Compositions with 0.005 % Fe max. and 0.005 % Ni max., for improved resistance to salt water are required by these specifications. (Dowmetal J-1, O-1, X-1, and AMC 57s).
(f) Contains 0.5 % silicon.
(g) Extruded and stretched is the condition in which bar and rod is normally furnished.
(h) Contains 5.0 % tin.
(i) Contains 3.5 % cadmium.

Critical Points

By The Editor

Lunched with Arthur Green, research metallurgist for Pratt & Whitney Aircraft Corp., and inquired about deliveries of raw materials. On being told that the metal makers were meeting quality requirements with little trouble, facetiously remarked that Green should stiffen up on the requirements. But really, these are already so severe that the standard extra for steel of "aircraft quality" (in accordance with the American Iron & Steel Institute procedure) is charged largely to cover the extraordinary amount of acceptance testing. Steels for many parts require that first, middle, and last ingot in each heat be sampled in the billet and tested variously for composition, segregation and inclusions. Finished bars from the same locations are then tested for tensile strength, grain size, and surface checked for microscopic flaws by magnaflux, not only once but three times, after successively turning to smaller diameter. Each finished bar is marked for heat number, ingot number and position in ingot, and an end disk cut for deep etch test. This extreme care for soundness and quality has been intensified during the last ten years of slow business, when the purchaser was in a position to enforce his requirements. It would seem to be a fact that the interplay of metallurgical requirements, as expressed by producer and consumer, has raised the quality of fine American steels above that now being made anywhere. (In other countries the attitude is still what it was here 25 years ago; the producers believe they know what is best for the consumer, and that is an attitude not very conducive to progress.) Superfine raw materials enable Americans to manufacture aircraft engines capable of running in continuous operation far longer than a good French or German engine. Green also says that, despite the utmost care in selecting raw material, defects show up now and then during machining or on final inspection of completed engine parts.

Superfine Metals for Air Engines

To a pair of interesting technical sessions — one S.A.E., the other — both provocative of the question-and-answer type of discussion. Miklos Hetenyi of Westinghouse Research Laboratories said that photoelastic analysis, or the study of stress distribution in loaded transparent models viewed with polarized light, was known in principle for a century and a quarter and the complete mathematical treatment has been available since 1850. However, no great industrial use was made until models of celluloid rather than glass were suggested. Celluloid is not only vastly more convenient to handle but is several times as active optically — that is, gives larger number of interference fringes for a given loading. Within the last decade phenolic condensation products such as bakelite have been found to be even better. Solid models (as a shaft with a keyway) can be shaped in stress-free bakelite, loaded as in service, and the internal stress distribution "frozen" in the solid by a short heating at 120° C. Fortunately these internal stress patterns are so firmly fixed that the solid model can be sawed apart without disturbing them and the stress distribution photographed in any elementary slab or section as desired. Hetenyi also outlined techniques for studying centrifugal stresses in disks rotating at high speed, and stresses in power-line insulators. Oscar Horger, who is studying the endurance limits of full-sized railroad axles (among other things) at the Canton plant of Timken Roller Bearing Co., said that the comforting thing about photoelastic analysis is that its indications are all on the safe side, even though the margin of error becomes smaller as the dimensions of the piece become greater, or the grain size of the metal becomes finer.

Solid Models, With Stresses Frozen in for Analysis in 3 Dimensions

Much impressed by the progress made by the gray iron foundries, despite the extreme decentralization of the industry, in improving

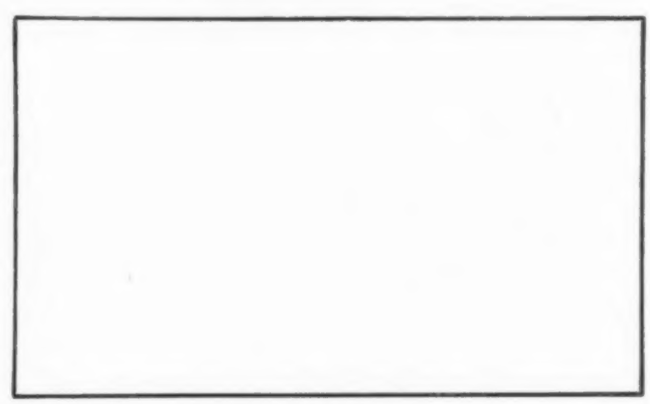
the product to meet the demands of important customers. Sometimes the tensile properties are quite secondary to the unique fitness of gray iron for certain services like brake drums, clutch plates and cylinder liners, but the stress of competition with other materials is responsible for much improvement in strength without undue damage to machinability. Maybe no objection was heard because there were no promoters of rival melting equipment present at the ASM meeting when RICHARD SCHNEIDEWIND of the metallurgical faculty of University of Michigan plumped hard for cupola iron as the best, unless special finishing treatment is given in the ladle to other types of iron — primarily, he said, because the metal is in contact with hot gases or refractories for a minimum time, say 10 min. at most. Nevertheless, this is undoubtedly the consensus of British iron founders as well.

Criterion for an A-1 Gray Iron

Most intriguing thing in foundry practice is the use of ladle deoxidizers (such as calcium-silicon) in an iron which is already balancing between two impulses — its silicon urging the carbon to graphitize and soften, and its manganese and chromium urging it to remain as carbide and harden. SCHNEIDEWIND proposed a useful criterion for excellence: The tensile strength of a gray iron divided by its Brinell hardness should give a quotient of 200 or more. In other words, a good foundry making a 40,000-psi. iron can hold the hardness to 200 or less, whereas iron that strong from a poor foundry will be considerably harder — more like 250 Brinell. Another important point: If good toughness and high strength are *both* desired, get it in a pearlitic or alloy iron *without* heat treatment, because quenched and tempered castings never have the impact strength they have as-cast.

TALKING with a group of steel makers about manganese, a strategic metal if ever there was one. The United States mines very, very little ore of ferromanganese grade, despite a tariff of many years' standing designed to foster domestic production. Most of the world's supply comes from southern Russia, India and South Africa. Some is available nearer home, from Brazil and Cuba. We simply haven't any in the States. Acute shortage during World War I forced the price to 22¢ a pound (normally about 5¢), intensified prospecting and frenzied development of prospects. These are certain to recur if the present European war destroys as much shipping as the last one. Electrolytic processes have recently been developed for the production of metallic manganese; the present price is 50¢ a lb. and while a considerably lower price is not unlikely, it cannot now be counted on as a source of cheap manganese. These considerations have been behind the periodic editorializing in METAL PROGRESS on the desirability (no, necessity) of using some of our buried gold to build up a stock pile of foreign ore. It probably is no alarmist attitude to speculate on how much ferromanganese could be saved by rigid parsimony. In the production of open-hearth steel, alloy grade, it unfortunately does little good to start with high manganese pig iron, for it will melt to only a few points higher manganese than low manganese pig. A more fruitful economy would be to revert to coarse-grained, low manganese steels from the fine-grained steels now in demand with manganese on the high side. They would not be so handy to consumers, but would be adequate for most purposes. Another way would be to substitute nickel and chromium steels for the low manganese alloy steels of recent popularity. Still another present use of manganese is for steels of high physicals in the as-rolled condition; equal strength but lower ductility may be had from higher carbon, lower manganese analyses. While these expedients, which might make 20 lb. of ferro serve where 25 is used now, would seem like a long step in the wrong direction, they might be forced upon us. In that event, ASMembers would be as useful in guiding the retreat as they have been in leading the advance.

What Can We Do About Manganese?



The Above Graph Evaluates the Problems That Will Probably Be Solved by the Present European and Asiatic Wars. Data from The History of Mankind

A study of the properties of plate embodying more than one composition in a single final section, produced by a new and commercial melting technique called "Pluramelt", metallurgical details of which are reserved for later presentation

Plural Compositions From a New Melting Process

In no branch of metal fabrication has there been more effort made than in that of combining the new and expensive "stainless steels" with the cheaper and stronger carbon steels. The chemical industry, the petroleum industry, the food and beverage industry, the paper industry — all use vessels that require strength against the pressures carried, and resistance to corrosive liquids or gases. High pressures sometimes demand wall thicknesses of two inches or even more of strong steel, yet only the inner surface of this must resist the corrosive contents. It seems extravagant to make a vessel of solid stainless steel when a thin layer of stainless over a plate of medium carbon steel would serve just as well.

Considerable progress has been made and many difficulties have been overcome in the production of stainless clad materials. Several firms use the old process of heating slabs of the two metals in contact and then rolling or forging the combination. A second method is that of pouring the liquid melt of carbon steel around a solid section of stainless steel. A third method has been to build up a series of thick overlapping beads of stainless steel weld rod deposit on a carbon steel backing, then machining the surface and rolling the combination to finished size — evidently a costly operation for a product that is likely to contain many imperfections in the weld metal.

More success has been achieved by the method of placing a thin sheet of stainless upon a steel plate of proper thickness and then spot welding them together on close centers by electrical resistance methods.

Robert K. Hopkins, as director of metallurgical research for The M. W. Kellogg Co. of Jersey City, N. J., was convinced that in order to obtain a material that would fulfill the requirements of the petroleum industry for pressure vessels such as his firm manufactures, it would be necessary to depart radically from all previously conceived methods and that the desired result could be accomplished only by the development of a new melting technique. Research was started and a thorough investigation was made of all known melting processes.

It was found that ingots produced by all of the present-day steel making processes have certain characteristics in common. Each ingot is formed from the freezing of a melt of single composition so that the final ingot is of relatively uniform composition throughout. In properly deoxidized steels, no dependence is

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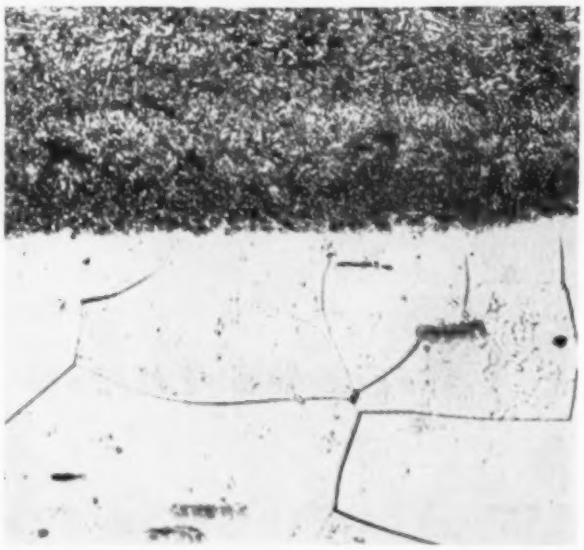
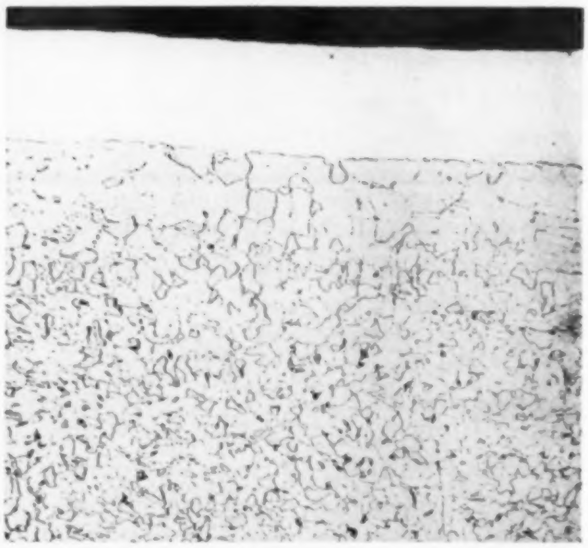
placed upon the hot rolling or mechanical working for the bonding or joining of the particles in any portion of the metals. Because of the singleness of composition of ingots produced by these well-known methods, these processes could be termed "monomelt". In the production of clad materials, it was, therefore, essential that both component analyses be, at least in part, *molten* at the same time, in order to secure absolute metallic continuity. Such a process could evidently be described by the words "plural melting" or simply "pluramelt".



At Left: Micrograph at 500 Diameters of Junction Between 13% Chromium Steel (Quenched and Tempered) and Low Carbon Steel Base, Showing Rapid Change From One to Another



Below: Nital Etch of 18-8 on Carbon Steel Sheet Shows Cleanliness of the Austenitic Steel Layer (Clear Band)

After intensive investigation, this result was accomplished by means of a special type of electric arc melting furnace so designed that the melting operation could be carried on and the final product would be intermelted with any other metal part and allowed to solidify as an inseparable portion of the unit mass.

Long association with Allegheny Ludlum Steel Corp. and recognition of their experience in the production of stainless steels, prompted Mr. Hopkins to discuss the problem with the Allegheny Ludlum research staff and as a result the steel company decided to participate in the further development. This work culminated in the construction of a plant at Brackenridge, Pa., which is now in commercial operation under exclusive license from The M. W. Kellogg Company under the Hopkins patents.

Description of the process here will be postponed since details will be available in the near future. Suffice it to say that it is essentially an electric furnace melting technique, as a result of which all of the special composition materials and a small part of the low-cost materials are melted and integrally joined during this operation. The furnace proper is radically different from the conventional type of electric furnace, in that the functions of steel making and of the mold are combined. In this way special steels are melted and joined to low-cost steels in ingot form, thus producing Pluramelt ingots. The composition of the special steels is controlled simply and within the ranges specified in commercial practice of today. The points to be emphasized are that the process produces single ingots of two or more compositions, integrally bonded together, and that it is possible to change the composition, within limits, during the melting operation.

Experience so far has been limited to Pluramelts of stainless alloys (high chromium-iron and chromium-nickel-iron alloys) on soft or medium steel, and tool steel types on soft steel bases, but it seems very likely that the commercial success with these materials may be duplicated with any other alloy that can be melted in an arc furnace. High carbon steel can be added to mild steel (or vice versa), the low alloy S.A.E. steels used in any desired combination, hard alloys or tool steels for wear resistance can be put on slabs, rails, roll cylinders, or wheel treads. Likewise the high nickel alloys can be so treated. The

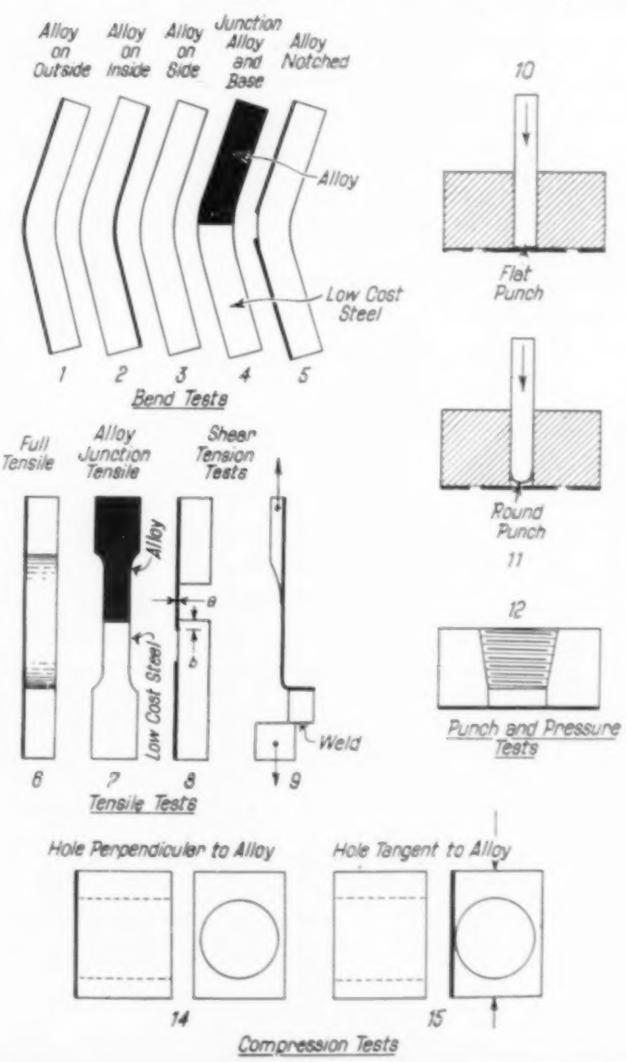
base metal can be covered on both sides and triple or more layers made of any desired proportionate thicknesses.

Thus far the materials which have been successfully produced are Allegheny Metal 18-8S (low carbon, 18% Cr, 8% Ni); the same with columbium, molybdenum or both; low carbon 13% chromium steel; and various tool steel compositions for the alloy portion, and low carbon and carbon-molybdenum steels for the massive portion. In the majority of cases the massive material is plain low carbon steel. Ingots have also been produced of three compositions integrally joined. These ingots have been processed into plates and sheets. Pluramelt wire has also been produced.

Nature of Joint

So much for the process. What of the product?

Tests to Prove Soundness of Bond Between Carbon Steel Base and High Alloy Steel Surface Layers



Its principal requirements are *(a)* a joint between compositions — base and surface layer — that is flawless; *(b)* uniform and correct composition in both base and surface layers; *(c)* ease in fabrication.

A micrograph is shown opposite, at 500 diameters, of a joint between 13% chromium stainless steel and low carbon steel base. Another at 100 diameters shows a Pluramelt sheet in which the alloy is 18-8; the sample has been etched in nital which attacks only the carbon steel and the freedom of the alloy from non-metallic inclusions is clearly evident. It will be observed that the transition from one to the other is not gradual. Likewise large areas of corrosion resistant surface recovered from samples of Pluramelt whose carbon steel backing had been entirely removed by acid exhibit a remarkably smooth surface. Many physical tests have shown extreme tenacity between the various compositions and these will now be described.

Bend Tests — The accompanying sketch shows the types of free bend tests that have been made, and are self-explanatory except possibly No. 4, which was made from a piece with a very thick layer of alloy; it may be considered a radial bend. In No. 5 a short length of alloy was machined away, leaving sharp re-entrant corners at its base. In all the tests the sections are bent cold until ends of the test bars meet. Elongations of outer fibers on bend bars are about 45%. There is no sign of parting of the special material away from the massive backing portion in any of them; neither is there fissuring or other failure of the alloy materials. The first two bend tests shown are perhaps not unusually drastic but the side bend, radial bend and notched bend (No. 3, 4 and 5) stress the "junction line" severely. It has been proven by many repetitions of these tests for several compositions that Pluramelt steels are integral and behave similarly to sections of monomelt steels. Sections have also been tested with alloy on both sides, and these act similarly.

Tension Tests — In specimens cut from a plate, like No. 6, and pulled in a tension machine, the special composition material at the side and the massive material deform together, both compositions necking down without parting. When the two compositions have different yield points, two separate "drops of the beam" will occur. It has been found that the special materials will add to the tensile strength of the base by an amount equivalent

to the strength of the actual mass of the special material present.

As may be anticipated, the tensile data are similar to those for a test piece of the base metal. Specifically we cite pieces cut from manway trim from a pressure vessel in shop fabrication. The plate was 1¼ in. thick with $\frac{1}{16}$ in. alloy facing (13% Cr, 0.10% C max.). The vessel — and test pieces — had been annealed 2 hr. at 1450° F., furnace cooled, and stress relieved 2 hr. at 1225° F., and furnace cooled. Four test pieces showed from 69,200 to 71,100 psi. ultimate strength and from 23 to 25% elongation in 8 in.

Results of Huey Corrosion Test, Using Boiling 65% Nitric Acid

Heat Treatment	Chemical Analysis					Inches Penetration per Month					
	C	Cr	Ni	Mo	Cb	First 48 Hr.	Second 48 Hr.	Third 48 Hr.	Fourth 48 Hr.	Fifth 48 Hr.	Mean Rate
a	0.07	19.3	9.7	None	None	0.00053	0.00040	0.00037	0.00040	0.00036	0.00041
b	0.09	18.1	9.2	None	0.70	0.00055	0.00056	0.00053	0.00054	0.00057	0.00055
b	Same containing an arc weld *(c)*					0.00085	0.00101	0.00108	0.00112	0.00124	0.00108
a	0.08	17.8	9.3	3.5	0.6	0.00085	0.00082	0.00080	0.00078	0.00084	0.00082

(a) Heat treatment: 1950° F., air cooled.
(b) Heat treatment: 1600° F., air cooled; 1150° F., furnace cooled; to simulate pressure vessel practice.
(c) Chemical analysis of weld metal: C 0.10, Mn 0.77, Si 0.57, Cr 19.60, Ni 8.98, Cb 0.63.

Many tests like No. 7 show that in such a bar failure takes place some distance from the junction of the two steels in the weaker material. In No. 8 an attempt was made to measure the strength in shear along the junction line; the exact value is uncertain owing to the eccentric loading, but failure occurs in section *a* rather than in shear until dimension *b* approaches the thickness of the overlay. When failure occurs at *b* it invariably does so along the 45° shear plane in the base metal and not at the junction. Test No. 9 was also designed to test the "bond". The original piece selected is a rectangular section of Pluramelt with the alloy steel on one side only. The massive material is machined away at the center of the bar, after which the specimen is bent 90° at the bottom and an attachment welded on so that the "junction line" is tested directly in tension. Many such tests on different compositions show that failure takes place in the thin alloy section with no peeling away of the alloy from the carbon steel.

Punch Tests No. 10 to 12 were prepared by drilling through the massive carbon steel, laying bare the underside of the special composition. Using either a sharp punch, a cupping punch or hydraulic pressure, the alloy diaphragm bulges or shears without lifting any of the alloy from the base metal. In the punch tests No. 10 and 11 a circular channel was cut through the layer of special composition at about three times the diameter of the punch; thus the punch thrust was resisted by an annular area of junction surface.

Compression Tests were prepared by drilling square blocks as shown in No. 14 and 15 and squeezed vertically until the sides collapsed. No parting could be observed in these pieces (see page 168).

Square bars have been twisted cold more than 720° without failure. Blocks and heavy plates have been quenched 20 times from 1200° F. by a water spray striking the alloy face only. Considerable distortion was observed, in the form of permanent growth in some directions and shrinkage in others, but no cracking or separation took place.

Such repeated tests on varieties of stainless steels on carbon and low alloy steel backings have proven that the joint is flawless.

Uniformity of Composition

Next we should consider the uniformity of composition — obviously a matter of extreme importance. The noble surface must not only have the intended composition, on the average, but there must be no segregation or major variation, point to point. While much detailed study has proven this point, the case can probably be demonstrated by studies of a low carbon, 18% chromium steel intermelted with a plain carbon steel base.

It is important to note that the portion of the base material which was melted has been completely dissolved in the low carbon alloy layer, and samplings taken at different locations, top to bottom and point to point, show no more than incidental variations in analysis. This is illustrated by the following ingot analyses:

Depth Below Surface	% Cr
At surface	18.3
¼ in.	17.9
½ in.	17.9
¾ in.	17.8
1 in.	18.1
1¼ in.	18.0
1½ in.	18.1
1¾ in.	18.2

So much for major segregation. Minor segregation is most readily shown by drastic corrosion tests, wherein micro-segregates are attacked more readily and result in frosted, pitted, or depressed surfaces. Several hundred corrosion tests have been made of the alloy portion of Pluramelt in a great many corrosion media in the laboratory. (In each case the carbon steel portion has been removed for preparation of the alloy test specimen.) Media which have been investigated are:

- Boiling 65% HNO_3 (Huey test)
- Strauss solution, boiling
- Nitric hydrofluoric acid, 170° F.
- H_2SO_3 (1%, 3%, 6% at 70° F.)
- 1% H_2SO_4, boiling
- 2% HCl, boiling
- 10% acetic acid, boiling
- 3% H_3PO_4, boiling
- 10% tannic acid, boiling
- 85% acetic plus ½% oxalic acid, boiling
- 20% NaOH, boiling
- 20% NaCl, boiling
- 20% $NaNO_3$, boiling
- 20% $ZnSO_4$, boiling
- 10% NH_4Cl, boiling
- 85% orthophosphoric acid at 350° F.

Resulting data are too voluminous to present here but it is definitely shown that the alloy portions show corrosion rates practically identical to similar alloy compositions made by conventional electric furnace processes. This has been borne out by results in service.

Results of representative tests in boiling 65% nitric acid are given in the table on page 166. Samples after heat treatment *(b)* were tested in the Strauss solution (48 hr. in boiling 1% $CuSO_4$ + 10% H_2SO_4) and 1 hr. in 3% HF + 10% HNO_3 at 170° F., and in all cases they could be bent flat without fissuring, they retained their metallic ring, and gave no evidence of intergranular corrosion.

One test in 75% "food grade" orthophosphoric acid is also illuminating. In it, a sheet made by conventional methods was compared with the stainless layer removed from a Pluramelt plate. Inches penetration per 1000 hr. were computed on samples, one air cooled from 2000° F. and stress relieved at 1150° F., and the other air cooled from 1600° F. and stress relieved at 1150° F. In both cases the Pluramelt was more resistant:

	Commercial	Pluramelt
Analysis: Carbon	0.06%	0.09%
Chromium	18.0	19.0
Nickel	10.9	11.0
Molybdenum	3.2	3.1
Columbium	None	0.43
Penetration; 2000° F.	0.139 in.	0.116 in.
1600° F.	0.127 in.	0.101 in.

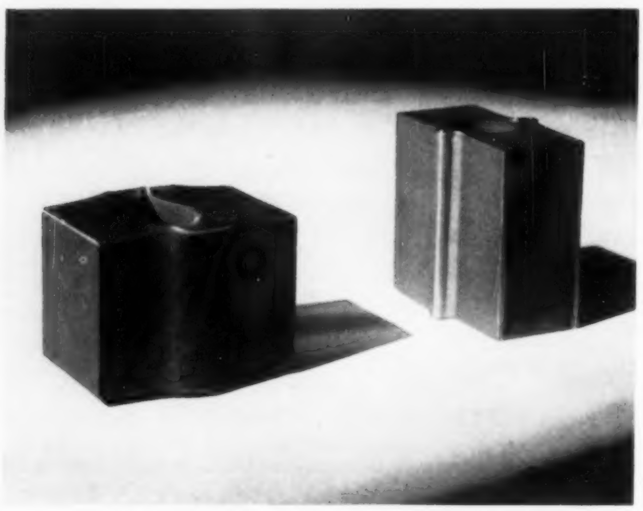
Pressure Vessel 12 Ft. Inside Diameter and 30 Ft. Long Weighing 80 Tons. Pluramelt plate 2⁹⁄₃₂ in. thick required to resist 215-lb. operating pressure at 800° F.

Minor segregation can also be discovered by microscopic examination. Thorough search indicates that the Plurametal structures are similar to those from conventional electric furnaces after equivalent heat treatments.

Fabrication

Finally, some words may be said about fabrication properties. Ample shop experience with Pluramelt indicates that it lends itself well to shop practices. Many pressure vessels from a few hundred pounds to over 100 tons have been fabricated by welding in the usual way.

From the foregoing account it may be concluded that the new process of manufacturing composite steels and alloys is commercial even



Type of Destructive Compression Tests Made in an Endeavor to Find if Any Type of Mechanical Abuse Could Impair the Bond

for the manufacture of heaviest pressure vessels. Success with stainless steels, always somewhat sensitive to slight errors in manufacture, indicates that the process may readily have much wider application. Future experience is necessary to indicate the economical limits of rolling. For instance, the saving in first cost of raw material in a thin sheet may not be of as much importance as a gain in the case of fabrication, such as in deep drawing, of a sheet with a ductile backing. Likewise the combination of alloys, one having strength and the other great hardness, toughness or wear resistance, is an unexplored field of great importance.

Protective Coatings for Magnesium Alloys

By T. P. Hoar

Abstracted from *The Metallurgist*, Oct. 27, 1939, p. 67

Magnesium and its useful alloys must be well protected against the attack of industrial atmospheres and sea water. The general treatment is a 0.5 to 2-min. dip in a solution containing 1.5 lb. of sodium dichromate and 1.5 pints of nitric acid (1.4 sp.gr.) to 1 gal. of solution. (Careful degreasing is a prerequisite.) This is known as "chrome pickle" in the U.S., and *mordancage* in France, and produces a complex protective coating of sparingly soluble chromic chromates which is porous but a good foundation for paint. If followed by two coats of a proper air-drying paint, the article will resist salt spray for one month. No pitting has been observed in such parts on seaplanes after one year's use. If extremes of temperature are to be resisted, the article may be baked at 350° F. (which possibly sinters some of the particles on the coating) and coated with two layers of a baking varnish, the second one pigmented with aluminum. For magnesium alloys containing 10% or more aluminum, a mixed coating of chromium and manganese oxides may be formed by dipping 30 sec. in a water solution at 200° F. containing 1% powdered alumina, 10% chromic anhydride, 5% hydrated magnesium sulphate and 1% caustic soda.

Mordancage forms a porous coating of relatively insoluble oxides and the pores are then filled with varnish or paint. Electrolytic methods have been proposed and are in use to a certain extent in France for filling these pores with silicates or with mixed basic fluorides. A superior silicate coating or filling can be made by exposing the magnesium to an alternating current at 50 volts or more in a bath containing alkaline silicate and caustic alkali with a comparatively high $SiO_2 : Na_2O$ ratio. This is not, however, a good undercoat for a protective paint.

Good protective coatings can also be built up on clean magnesium by alternating current electrolysis in an acid bath made by adding considerable manganous carbonate to a chromic acid solution. Initial voltage of, say, 20 volts falls to about 8 volts, and a brown coating of manganous oxide is formed, a very good support for paint.

The fluoride treatment is best for the 1.8% manganese alloy most suitable for resisting salt water. It is rather lengthy, *(Cont. on page 180)*

More than 40 aluminum alloys now commercially made into castings and forgings are classified and some general rules laid down for machining them. A second article will discuss individual operations, like turning or milling, and recommend proper tool shapes

Machining of Aluminum Alloys Cast or Wrought

THE REMARKABLE INCREASE in the use of aluminum and its alloys has been accompanied by a need for detailed information on the properties of the numerous commercial alloys. An engineer first wants to know the physical and mechanical properties of a particular material and, when he finds it will perform satisfactorily, he then is interested in some of its other characteristics. Of these, machinability is one of the most important.

In the present paper the alloys (designated by Aluminum Co. of America nomenclature) are divided into groups according to whether they are cast or wrought, heat treated or not heat treated. The general machining characteristics of each group are described, and certain principles common to the machining of all aluminum alloys are considered. In a subsequent paper specific operations as turning, milling and drilling will be discussed. Frequently speeds, feeds, and cuts which will produce satisfactory results under favorable conditions will be suggested. Aluminum alloys may be readily machined with equipment and tools generally available, provided a few principles are followed; however, as with all metals, tools and equipment of special design are sometimes desirable for maximum production. No attempt is made to discuss the use of aluminum alloys in screw machines since this was done by L. W. KEMPF and the present author in METAL PROGRESS for July 1935 and by L. W. KEMPF and A. HARTWELL in the same magazine in the issue for December 1936.

By Walter A. Dean
Aluminum Company of America
Cleveland

Alloy Classification

There are several ways of classifying aluminum alloys for a discussion of machining characteristics; however, the grouping suggested in the table on page 170 appears to offer fewest objections. The groups in general are not competitive but, within any one, the selection of an alloy for a particular job is often influenced by the way it machines.

Sometimes it is difficult to distinguish between the machinabilities of two alloys, for so much depends upon the relative importance attached to the various factors. One or more of these factors may be in disagreement with the general evaluation of an alloy; for example, a smooth surface, small chips and absence of burrs may be accompanied by appreciable tool wear. Consequently, the reader is cautioned against attempting to draw a sharp line of distinction between the machining properties of alloys placed close to each other in the table. The fact is that each group contains alloys with excellent machining characteristics as well as

others which can be cut satisfactorily if certain precautions are observed.

Non-Heat-Treated Casting Alloys — In this group are some of the finest machining aluminum alloys commercially available. Others, however, may present definite problems. Experience indicates that certain general effects may be predicted from a knowledge of composition. For instance, alloying additions which do not form extremely hard or very abrasive constituents, such as copper, zinc or magnesium, tend to improve the machinability of aluminum. On the other hand additions such as silicon or manganese, forming hard abrasive constituents, are likely to impair machinability by increasing tool wear. The mechanism by which many additions to aluminum influence machinability is not clearly understood, consequently much of the information available is of an empirical nature, and the only certain way of determining the cutting characteristics of an unknown alloy is to try it in the operations to be performed.

It is generally true that machined surfaces of the aluminum-magnesium alloys are shiny and frequently very smooth while the turnings are loosely wound. The aluminum-copper and aluminum-zinc alloys machine to somewhat duller surfaces while the chips are more tightly wound. Aluminum-silicon alloy surfaces are dull gray in color and the chips are rough, having the appearance of being torn from the stock.

When the same alloy cast in sand and in a permanent mold is machined, the sand casting has a slightly rougher surface, but both produce chips similar in appearance when cut under the same conditions.

The excellent machining non-heat-treated alloys 173, C113, 645 and B113 can be turned, milled or drilled using highest speeds, feeds and cuts. Frequently no lubricant is required — or if one is indicated an inexpensive compound such as soluble oil may be used. The tool may have relatively small rake angles. The machined surface is smooth, dimensions are maintained without difficulty and there is little or no tendency for the tool to leave a burr or for the chips to build up on the cutting edge.

Alloys of Type II have good machining properties but perform best at somewhat lower feeds and cuts than above. The top-back and top-side rake angles should be increased and a good lubricant used to counteract any tendency towards development of burrs, build-up of chips on the tool, or the production of rough surfaces. Turnings are longer than from Type I alloys.

The remaining alloys not heat treated (Type III, namely, 172, A108, 108, 356 and 43) have fair cutting characteristics but sometimes require special care to machine satisfactorily. Further reductions in feeds and cuts, accompanied by an increase in top-back and top-side rake angles of the tool, are indicated to obtain

Commercial Aluminum Alloys

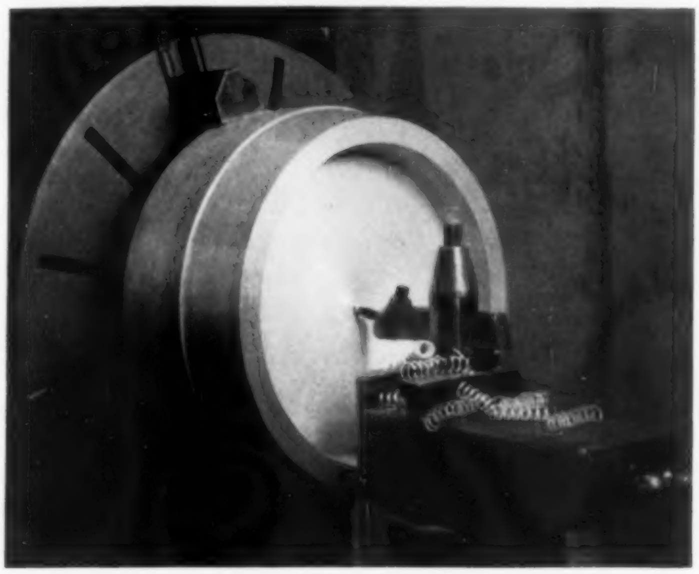
Type	Alcoa Alloy	Composition				
		Cu	Fe or Mn	Si	Mg	Other
		Non-Heat-Treated Casting Alloys				
I	173	7.0				2.0 Sn
	C113	7.5	1.2 Fe	4.0		2.0 Zn
	645	2.5	1.5 Fe			11.0 Zn
	B113	7.5	1.2 Fe	1.5		
II	112	7.5	1.2 Fe			2.0 Zn
	216				6.0	
	A214				3.8	2.0 Zn
	109	12.0				
	12	8.0				
	214				3.8	
	212	8.0	1.0 Fe	1.2		
	B214			1.8	3.8	
III	172	7.8		2.5		
	A108	4.5		5.5		
	108	4.0		3.0		
	356			7.0	0.3	
	43			5.0		
		Heat-Treated Casting Alloys *(a)*				
I	220 *(b)*				10.0	
	122	10.0	1.2 Fe		0.2	
II	D195	5.5		0.7		
	142	4.0			1.5	2.0 Ni
	195	4.0				
	B195	4.5		3.0		
III	355	1.3		5.0	0.5	
	A355	1.4	0.8 Mn	5.0	0.5	0.8 Ni
	356			7.0	0.3	
(c)	A132	0.8	0.8 Fe	12.0	1.0	2.5 Ni
		Heat-Treated Wrought Alloys *(a)*				
I	11S	5.5			0.5 Pb + 0.5 Bi	
II	51S			1.0	0.6	
	53S			0.7	1.3	0.25 Cr
	A51S			1.0	0.6	0.25 Cr
	17S	4.0	0.5 Mn		0.5	
III	25S	4.5	0.8 Mn	0.8		
	70S	1.0	0.7 Mn		0.4	10.0 Zn
	18S	4.0			0.5	2.0 Ni
	14S	4.4	0.8 Mn	0.8	0.4	
	24S	4.4	0.5 Mn		1.5	
(c)	32S	0.8		12.0	1.0	0.8 Ni
		Non-Heat-Treated Wrought Alloys				
II	56S		0.1 Mn		5.2	0.1 Cr
III	4S		1.2 Mn		1.0	
	52S				2.5	0.25 Cr
	3S		1.2 Mn			

(a) Heat treated as usually sold, namely a solution treatment followed by aging at room or elevated temperature.

(b) Alloy 220 is not aged.

(c) Alloy cuts freely, but wear on tools may be excessive unless they are tipped with cemented carbide.

smooth surfaces, reduce the formation of burrs and overcome the tendency of the turnings to build up on the tool. These alloys are somewhat gummy when machined. A good lubricant, such as a mixture of lard oil and kerosene, is very desirable. These alloys machine well with properly ground tools of the cemented carbide type.



Turning a Forging of Alloy 14S With High Speed Tool, Lubricated With Kerosene. Diameter 20 in., cut 1/8 in., peripheral speed 650 ft. per min., feed 0.050 in. Note long, curly chips

Heat Treated Casting Alloys — Heat treating a casting at low temperatures improves its machinability slightly. The tendency is to shorten the turnings. The effect of heat treating a casting at high temperatures is to dissolve, in solid solution, certain of the constituents present in the as-cast structure. These constituents may or may not be subsequently precipitated under controlled conditions, depending upon the use in service. In commercial castings, certain constituents remain out of solution and by their presence act to break up the chips; nevertheless, the effect of a solution heat treatment is to produce smoother surfaces and more continuous chips during machining. When such a casting is subsequently given a precipitation heat treatment by aging at a moderate temperature, there is not much change in the appearance of chips or surface, but tool wear may be increased because the alloy has been hardened.

Compositions of the heat treated casting alloys are shown in the table. The alloys 220, 122 and A132 can be machined at high speeds using moderate feeds and cuts. The chips are small, the surfaces are smooth, the tool produces little or no burr, and there is not much tendency for the chips to build up on the tool. Alloy 220 machines to the smoother finish, but 122 can be cut at greater feeds. If high speed steel tools are used on A132, tool life may be short; consequently, cemented carbides are particularly recommended.

Alloys D195, 142, 195 and B195 have good machining properties. Turnings are long, but generally tightly curled and the surfaces are smooth. If they become a problem, some reduction in speed is indicated. Turnings from 355, A355 and 356 frequently are long and loosely curled. Chip clearance may be a problem, in which event use lower speeds. Machined surfaces are likely to be rough, which points to the necessity for reducing the feed and depth of cut. Burrs are heavier and chips tend to build up on the tool. Consequently the use of a lubricant which penetrates is particularly recommended, together with a tool whose cutting edges are well cleared all around.

Heat Treated Wrought Alloys — The limitation imposed by the ability to fabricate an alloy for a particular job, together with the properties demanded by the application, largely determines the nature and amount of constituents present in the microstructure of a wrought aluminum alloy. The aluminum-magnesium-silicide alloys are very easy to forge, have high properties after suitable heat treatment, and in this condition are essentially solid solutions. The aluminum-copper and aluminum-zinc alloys are more difficult to forge, have very high properties after heat treatment, and in their simple form are largely solid solutions. In their commercial form, however, moderate amounts of other elements are added to these alloys to develop certain properties. Some of these addition elements combine with aluminum, or with aluminum and some other element already present, and these constituents frequently remain as distinct phases in the heat treated alloy. In a general way the alloys containing only a small amount of secondary phase form long continuous turnings and, if no burrs are developed on the cutting edge of the tool, the machined surface will be smooth. With

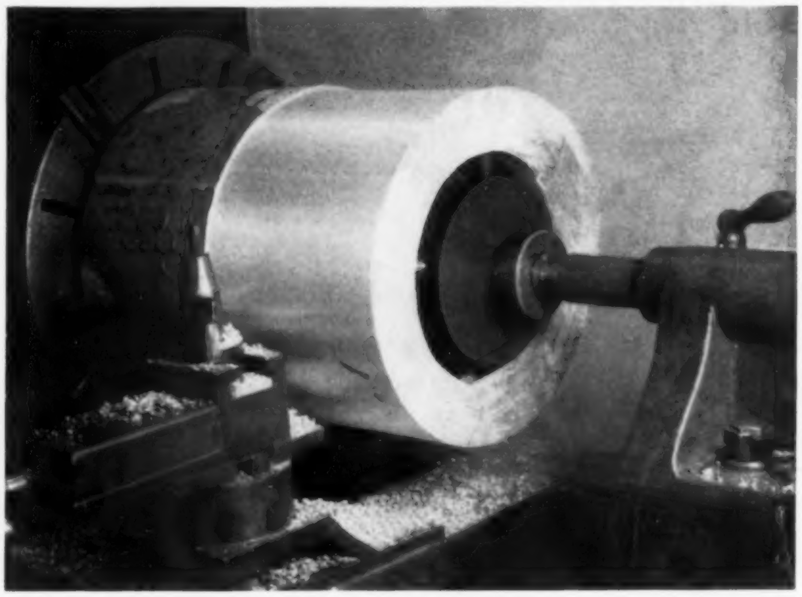
solid solution alloys there is a reduction in the tendency to develop a built-up burr as the amount of constituent in solution is increased. Where there is an appreciable amount of a secondary phase present, break-up of turnings is promoted but the production of smaller chips may be accompanied by an increase in the frequency at which the tools must be redressed. Thus, turnings from 32S are smaller when machined under similar conditions than those from any of the aluminum-copper alloys to which moderate amounts of magnesium, manganese, nickel or silicon have been added, but tool wear may be excessive when machining 32S unless tools tipped with cemented carbide are used.

In addition to the types of heat treated wrought alloys already discussed there is the one discussed in this magazine in 1935 and 1936, which was developed for high speed machining. This alloy, commercially designated 11S, is free-cutting, may be machined to a very smooth finish and when heat treated has high mechanical properties. There is no build-up on the cutting edge of the tool, when properly dressed, and tool wear is relatively quite low.

The heat treated wrought alloys shown in the table are characterized by the smooth surfaces to which they can be machined. From the foregoing discussion it follows that 11S is particularly applicable where excellent machining qualities are demanded of a high strength wrought alloy, whether this application be one of turning, milling or drilling. The treated and aged alloys 51S-T, 53S-T and A51S-T offer low resistance to the tool. When precautions are taken to prevent a burr from building up on the cutting edge, fine surfaces are obtained even when using moderately high cuts and feeds, but because of this tendency these alloys cannot be drilled as well as the aluminum-copper types.

Alloys 17S-T, 25S-T, 70S-T, 18S-T, 14S-T and 24S-T offer increasing resistance to the penetration of the tool because of their high physical properties. Furthermore, machinings from these alloys are frequently quite long; consequently it may sometimes be necessary to reduce the feed as well as the depth of cut. Where threading and tapping are important operations, 17S-T is particularly recommended.

Non-Heat-Treated Wrought Alloys — In common with other metals, the machinability of aluminum alloys is improved by cold working. However, the difference between the machining properties of the hard and soft



Turning a Sand Casting of Alloy 112 With a Sintered Carbide Tool and no Lubricant. Diameter 22 in., cut 1/8 in., peripheral speed 970 ft. per min., feed 0.015 in. Note fine chips

tempers of the same alloy is one of degree rather than of kind.

Turnings from 3S are continuous, tough, and difficult to curl; consequently, trouble is sometimes encountered in adequately disposing of them. It may even be necessary to interrupt operations, if chip room is limited as in drilling, in order to clear them away. This condition, however, may be counteracted by reducing the cross-sectional area of the turnings. In spite of the gummy nature of 3S and its consequent tendency to develop a built-up burr on the tool, the alloy in both soft and hard tempers can be machined to a smooth surface at moderate speeds and feeds if the tool has large top-back and top-side rake angles.

The alloy 4S has the advantage over 3S in that the turnings show a greater tendency to curl. This is a valuable property where chip room is at a premium. The turnings are of the continuous type, and the surface of the machined object is smooth even when taking the fairly heavy cuts permissible in lathe work,

milling or shaping. To a noticeable extent 4S is less gummy than 3S, but here again, tools are recommended with plenty of rake. Of course, a lubricant should be used. Turnings from 52S are likely to be continuous; the machined surfaces are not so smooth as those produced on 3S or 4S under similar circumstances, yet 52S can be drilled very readily. Under certain conditions, the production may be 15 to 20% greater with 52S than with 3S. Turnings from 56S are more broken up than those from the other non-heat-treated wrought alloys.

In general, the non-heat-treated alloys shown in the table are very easy to cut when measured in terms of their resistance to the tool. When their individual cutting characteristics are understood, satisfactory results are obtained.

General Machining Considerations

Tools

1. Use as large rake and clearance angles when machining Type III alloys of all groups as is compatible with economical tool life, so as to shear rather than tear the chips from the work. The free-cutting alloys of Type I, on the other hand, can be machined with relatively smaller cutting angles.

2. Use highest quality tools that the nature of the job will permit. Because of the somewhat acute cutting angles high speed toolsteels often are suggested, but for production runs tools tipped with cemented carbide are recommended if the work is free from vibration and irregularities.

3. Tools last longer when the cutting edge and surfaces supporting this edge are finished with a fine stone. In some instances buffing the tool has noticeably improved its life and also the quality of the machined surface. When cemented carbide tools are diamond lapped smoother machined surfaces are obtained.

Lubricants or Coolants

1. When machining the more free-cutting aluminum alloys (Type I) there is sometimes no need for either a lubricant or a coolant, particularly when making roughing cuts, although the nature of the job and the finish desired determine the procedure. Some of the other alloys form small burrs on the cutting edge of the tool. In these cases a coolant such as dilute soluble oil will keep the work cool and aid in clearing away the chips. If high speeds and feeds are employed or a heavy burr builds up on the cutting edge, a lubricant such as kerosene, kerosene and lard oil, a paraffin oil with or without additions of lard oil or kerosene, or any one of several commercially available screw cutting compounds will prove helpful. A fine quality of finish will be obtained with a lubricant having low viscosity and containing a fatty constituent. For hand tapping and reaming, the use of heavy oil or paraffin wax is suggested.

2. Be sure the lubricant falls on the tool or on the work in such a manner as to penetrate readily to the line of contact between tool and work.

Chips

1. Provide ample room for chip clearance.

2. If depth of cut becomes excessive, metal is no longer sheared from the stock. The chips build up on the cutting edge, are excessively work hardened, and ruin the finish as well as diminish the life of the tool.

3. Aluminum alloy machinings are quite valuable; therefore, protect them from contamination. Segregate machinings from different alloys when a premium is paid for controlled purity or composition.

Equipment

1. In general, use highest speed of which the equipment is capable together with moderate feeds and cuts.

2. In utilizing the high speeds recommended for machining aluminum alloys the work must be held rigidly and maintained free from vibration.

3. Aluminum alloys are light, hence large castings and forgings can be handled and supported in the ordinary machine shop without the use of special equipment.

Work

1. Aluminum alloys have higher coefficients of expansion than many other commercial alloys. Warping and distortion may occur if the casting or forging is excessively overheated during machining. Overheating may arise from the use of improperly designed tools, dull tools, failure to use a lubricant where indicated, as well as from the use of heavy feeds or cuts. Distortion is sometimes caused by improperly clamping the work in the machine.

2. If sand castings are to be machined, allow sufficient stock for finishing. Very little excess stock is necessary to clean up permanent mold castings or forgings.

3. The presence of foreign inclusions in the casting may seriously reduce tool life.

[Editor's Note — This article, of general nature, will be followed by another recommending tool shapes, speeds, feeds and other specific data for the various operations.]

Personals

Edwin C. Yaw ⊕ is doing research work in metallography for the Experimental Mechanical Engineering Department of Cornell University.

Reed G. Laird ⊕ is now metallurgist for Ohio Seamless Tube Co., Shelby, Ohio.

Stanley P. Watkins ⊕, manager sales development, Rustless Iron and Steel Corp. Baltimore, has received the annual Wire Association Medal Award for 1939, for the outstanding paper on wire manufacture or fabrication written by a member of the Association.

E. A. Burr ⊕, vice-president in charge of Cleveland Quarries Co.'s Firestone Division, has been elected a director of the company.

Appointed vice-president in charge of sales for the new Steel Division of Copperweld Steel Co. at Warren, Ohio: **Sidney D. Williams** ⊕, formerly director of sales for Timken Steel and Tube Division of Timken Roller Bearing Co.

Promoted by Crucible Steel Co. of America: **David K. Miller** ⊕ from district representative to manager of the Baltimore branch; **J. S. Billingsley** ⊕ to assistant manager of the Pittsburgh branch.

Transferred to the Cincinnati sales office: **Edward J. Egan, Jr.** ⊕, after a year's training at the Whiting, Ind. plant of Federated Metals Division, American Smelting & Refining Co.

C. E. Collander ⊕ has resigned from the Keystone Drawn Steel Co. to accept a position with Jacobs Aircraft Engine Co.

R. W. Emerson ⊕, development engineer, Westinghouse Electric and Mfg. Co., Trafford, Pa., is now metallurgist and welding engineer at Pittsburgh Piping and Equipment Co., Pittsburgh.

Philip Sievering, president of Philip Sievering, Inc., was honored at a banquet of the Masters' Electro-Plating Association of New York, celebrating the 50th anniversary of his entrance into the plating industry.

Maurice G. Steele ⊕, formerly technical adviser to the sales department, Baltimore division of Revere Copper & Brass, Inc., has joined the Kent Co., Inc., Rome, N. Y., as factory manager.

Appointed assistant general superintendent of the West Leechburg Division of the Allegheny Ludlum Steel Corp.: **George C. Floyd** ⊕, formerly superintendent of the alloy strip department.

Frank R. Mathews ⊕ and his son **James R. Mathews** have announced the opening of a commercial heat treating shop in the Newark area to be known as The Mathews Co.

Personals

Harbison T. Oatman is now junior research metallurgist at the research laboratory of the Allegheny Ludlum Steel Corp., Brackenridge, Pa.

James C. Vignos has been appointed director of research of Ohio Ferro-Alloys Corp.

Claus G. Goetzel, powder metallurgist, formerly with the Hardy Metallurgical Co., is now a member of the staff of the American Electro Metal Corp. at the new research laboratories for powder metallurgy in Yonkers, N. Y.

Alvin E. Hope has left Allegheny Ludlum Steel Corp. to join the Detroit office of Universal Cyclops Steel Co. as sales representative.

P. T. Roberts, formerly special apprentice with the New York Central Railroad at Albany, N. Y., is now service test inspector at Beech Grove, Ind., covering the Big Four district.

Richard M. Lord is now affiliated with the Aluminum Co. of America at its Alcoa, Tenn., fabricating plant, as metallurgist in the plate mill remelting department.

R. H. Lambert, student officer at the Naval Postgraduate School at Annapolis, is at Carnegie Institute of Technology for a year of graduate metallurgy.

Wilton F. Melhorn is a technical apprentice at American Steel and Wire Co., in Joliet, Ill.

Van Lear Rentzell of the Philadelphia Navy Yard testing laboratory has accepted a position as Army Air Corps inspector stationed at Glenn L. Martin Co.

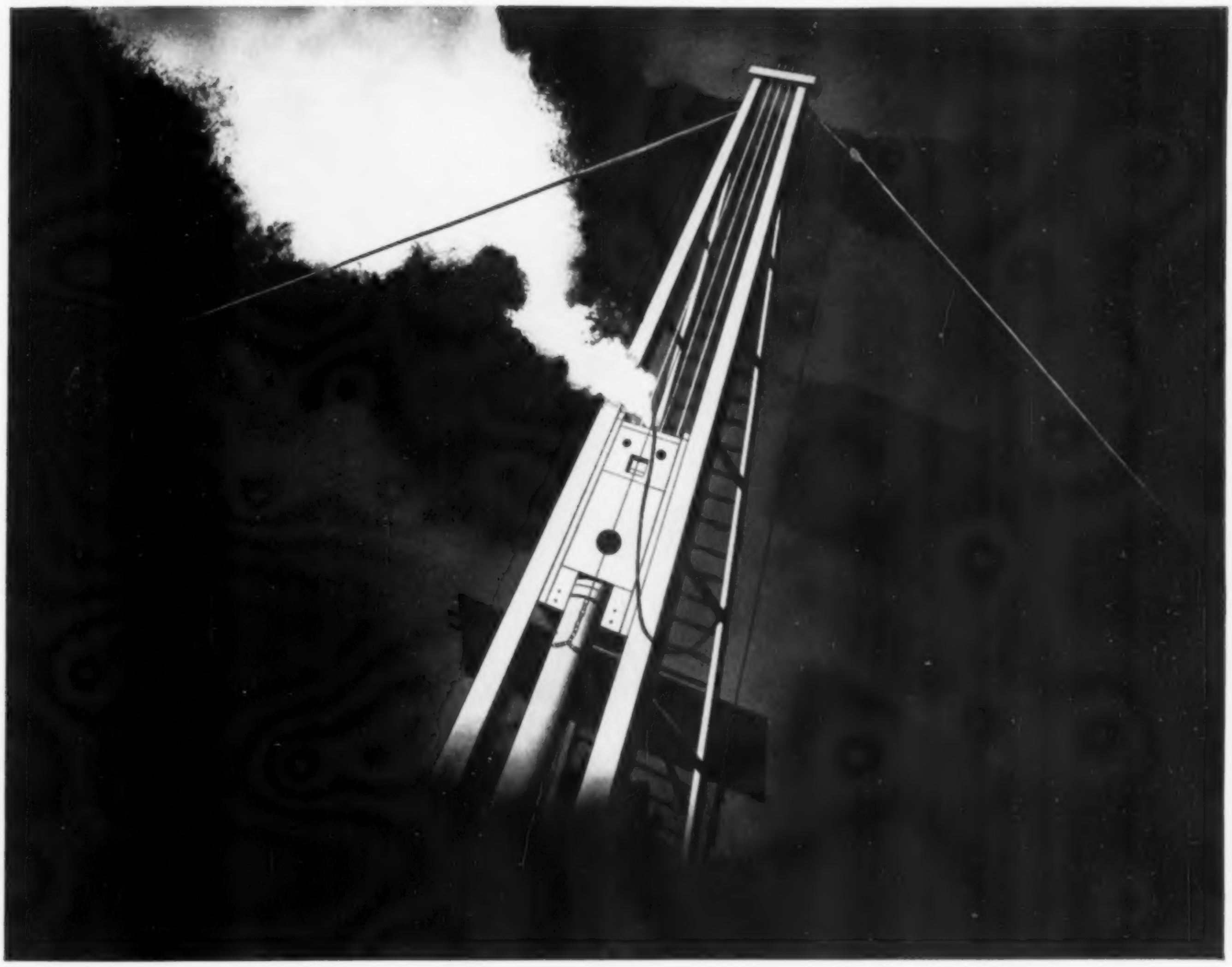
Retired: **Arthur G. Greenameyer**, as operating manager of the Buffalo district for Republic Steel Corp.

B. H. Gedge, manager of operations for the Cleveland district of American Steel & Wire Co., Cleveland, has been appointed assistant to the vice-president in charge of operations. **A. J. Hoyt**, assistant manager of the Worcester, Mass., district operations, has been appointed to succeed Mr. Gedge at Cleveland.

William Hovaten is now doing graduate work at the Colorado School of Mines on a research fellowship presented by the Great Western Electro-Chemical Co. of San Francisco.

Walter Grabowsky is now a junior metallurgist in the process control division of the Carnegie-Illinois Steel Corp. at the South Works in Chicago.

Frederick Cooper, formerly research associate at The Midvale Co., Philadelphia, is now assistant superintendent of the research department.



PILE DRIVERS CAN'T CALL "TIME OUT"

When a pile driver goes to work time is generally the essence of the contract, with penalties for non-fulfillment an ever-present threat. Hence the ability to give continuous service under difficult conditions and with a minimum of attention is an essential requirement. That, in turn, depends largely on the choice, for each part, of the material best adapted to the job.

One manufacturer, whose pile drivers have made an enviable record for trouble-free performance, guards dependability by making the ram piston — a vital part — of Nickel-Chromium-Molybdenum Steel. This steel develops to a high degree the particular combination of toughness, strength and hardness, in the heavy sections used, which is necessary to withstand the rigors of the service.

A re-check of your own materials specifications may disclose possibilities for increasing dependability by the use of Molybdenum Steels. You will find our technical booklet, "Molybdenum in Steel", helpful. It will be sent free on request.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

MOLY

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

Cold Work

(Continued from page 158)

The final grain size is the larger the smaller the deformation.

4. The larger the original grain size the greater the amount of cold deformation to give equivalent recrystallization temperatures and times.

In connection with these fundamental laws, it should be pointed out that the amounts of cold work to give equivalent strain hardening vary with the temperature at which deformation is performed.

Impurities in solid solution tend to increase the temperature of recrystallization of a metal but exert a minor influence on its grain growth characteristics. On the other hand, undissolved impurities are generally assumed to have little, if any, effect on recrystallization temperature. This latter generalization is somewhat questionable, since in several instances such impurities, in a fine state of subdivision, are more powerful in increasing the recrystallization temperature than elements in solid solution. Undissolved impurities exert a pronounced effect on grain growth; when present in relatively small amounts the grain size may be small at low temperatures but suddenly increases to unusually large size in a narrow temperature range; when present in larger amounts grain growth may be entirely prevented.

The last lecture of the series "Practical Annealing" was by E. G. DeCoriolis of the Surface Combustion Corp. This talk emphasized the continually changing requirements for annealing furnaces as methods and procedures changed in the metal fabricating industries. At the present time there appears to be a definite trend away from the "batch" annealing practice toward continuity of operation in "through" furnace. The speaker also dwelt at some length on the subject of controlled atmosphere annealing and carburizing.

After spending five afternoons and four evenings at this specialized clinic on the cold working and annealing of metals, your reporter was left with the distinct impression that there is still a lot to be learned about the subject. While the effects of plastic deformation, strain hardening, recovery, recrystallization and grain growth are recognized and used to advantage commercially, the detailed fundamental mechanisms whereby these phenomena function are still eluding satisfactory explanation. We are still in the "art" stage of development where progress is best accomplished by cut-and-try methods, properly seasoned with a dash of common sense.

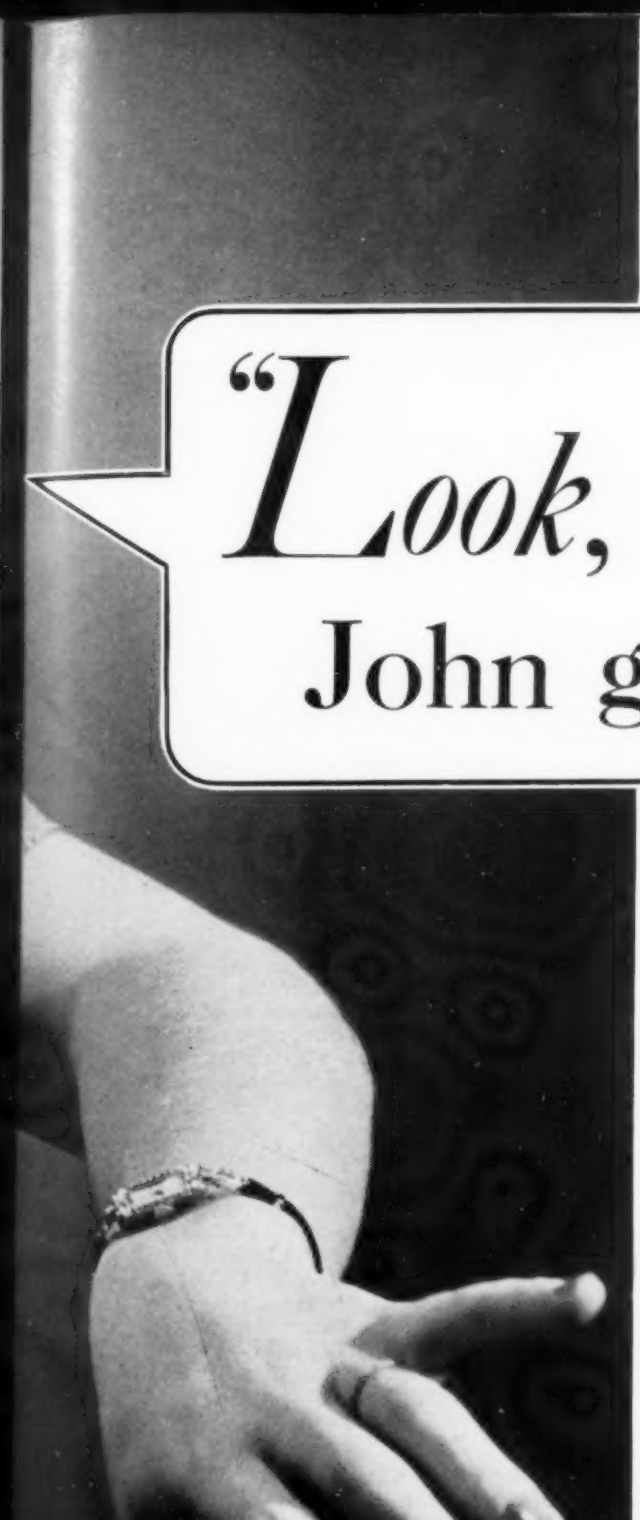
Magnesium

(Continued from page 168)

even in its simplest form consisting of 1 hr. in a solution containing 4% sodium fluoride and 4% sodium borate at 120° F. with 40 volts alternating current, followed by 4 hr. in a hot solution (180° F.) of 1% potassium hydrate and 10% potassium fluoride.

The above fluoride treatment was developed by Messrs. POMEY, FOURQUIN and HARDY of the Renault Co. in an exceptionally logical way. They first found that clean magnesium, when anodized in 10% potassium fluoride solution at 120° F., builds up a very thin insulating film of magnesium fluoride in 2 min., the current falling to 10% of its initial value and the bath voltage rising to the 40 volts of the supply used. This film, however, disappears when washed for 14 hr. with chloride solutions (as shown by re-anodizing the specimen, when the film may be built up again as at first.) Washing in 3% potassium fluoride solution scarcely affects the film, for on re-anodizing, the insulating condition is attained within a few seconds. Since the fluoride film is evidently insoluble in solutions containing an excess of a soluble fluoride, the investigators turned to more alkaline fluoride baths (containing carbonate or borate), and obtained mixed basic fluoride coatings. When these are washed with water and the specimens re-anodized, the insulating condition is quickly regained, showing that the films are less soluble than the normal fluoride, as expected. The next step was to augment the thickness by the use of alternating current; the cathodic part of the cycle does not reduce the basic fluorides formed by the anodic part, but seems to render the film more porous and thus to promote its thickening. If now the direct current process is applied to the film thus formed, it is rendered insulating; the two processes are largely additive. Finally, good mechanical resistance is achieved by a preliminary treatment in cold potassium permanganate solution acidified with acetic; this gives a porous, but flexible, coating of oxides of manganese.

Electrolytic processes seem to have advantage over simple dichromate *mordancage* where no subsequent paint or lacquer coating is to be applied. Painting is often a distinct disadvantage from added weight, and therefore there is a demand for some method that would render the metal passive. Therefore, these promising French treatments might well be simplified and shortened to facilitate their practical applications and to lower their costs.



"Look, Dad, John got his Raise!"

HE FOUND OUT HOW TO LICK THE JOB THAT HAD HIS BOSS SO WORRIED

JOHN SMITH is not his name—but he is shop foreman in a big electrical plant and this story *is* an actual fact. A few weeks ago he was talking to one of our metallurgical contact men about the steel for a new product his company was developing.

"Our people have about decided that alloy steel or high tensile steel is what we need," said John, "but the costs are way out of line. The job won't stand it. Got any bright ideas?"

After a study of the blueprints our man said, "John, unless you're dead set on some particular alloy I think I can save you a nice piece of change. You don't need a high-priced steel here. There's not a single specification you can't fill with our Controlled Steels. Look . . ."

Next morning, after a careful check-up, John took the figures to his boss. Three days later the order came through—for U·S·S Controlled Steel. When the first lot was ready for assembly, the Purchasing Agent called up John's boss. "Smart fellow, young Smith," said he. "That change in steel he recommended has saved the Company about $1200. Don't you think we ought to do something about that?"

So that's why Jane Smith is proudly sporting a nice new wrist watch today—and John is carefully saving a fat cigar for our salesman's next call.

Because we make steels of *every* kind we are able to look at your steel problems without bias or prejudice. If a low-priced steel will fill the bill we'll be the first to point it out. Our only concern—always—is to help you select the right steel that will do the best job for you, at lowest cost. This steel consulting service is free—it has saved many thousands of dollars for others—why not avail yourself of it?

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UNITED STATES STEEL

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● *Some of the foremost experts in the metal industry have contributed to the wealth of information contained in the literature described on this page. You will find your time well spent in looking it over. One booklet may solve your most difficult problem. Use the convenient coupon today to obtain this free literature.*

Non-Sparking Safety Tools

If your work is near inflammable gases, explosives, etc., the new 20-page catalog featuring Ampco non-sparking safety tools will prove interesting and valuable. Ampco Metal, Inc. Bulletin Bd-175.

Collegiate Furnaces

A 12-page folder showing Ajax-Northrup furnaces in ten colleges with statements of uses in each by professors and graduate students is now available through the Ajax Electrothermic Corp. Bulletin Bd-41.

Dilatometer

The new Rockwell-Bristol Dilatometer which both indicates and records in ink time-dilatation changes and temperature-dilatation changes simultaneously during heating and cooling cycles is described in a folder released by the Bristol Co. Bulletin Bd-87.

Contour Sawing

A virtual text on Contour Sawing, containing over 300 illustrations in its 160 pages, is now available through Continental Machines, Inc. Bulletin Bd-170.

Tool Steel

"Ketos" — a tool steel for making intricate tools — is described in a new folder by the Crucible Steel Company of America. Bulletin Bd-56.

Structural Metal

A complete and concise discussion of magnesium and its alloys is contained in the booklet "Industry's Lightest Structural Metal" which is made available through the Dow Chemical Co. Bulletin Bd-215.

Heat Treating Hints

A helpful, colorful booklet edited by experienced heat treaters is available through the Lindberg Engineering Co. Bulletin Bd-66.

Rayotubes

Specialized temperature measuring problems to which Rayotube detectors are now being applied are shown in an impressive booklet released by Leeds & Northrup Co. Bulletin Bd-46.

Flame Gouging

An economical method of grooving steel "Flame Gouging", is explained with operating data and illustrations in an 8-page folder released by The Linde Air Products Co. Bulletin Bd-63.

Machinability Chart

A quick and accurate picture of how Rustless Stainless Steel will respond to your shop operations is given in the "slide-rule" machinability chart available through the Rustless Iron & Steel Corp. Bulletin Bd-169.

Ferrocarbo

A cupola addition, "Ferrocarbo", which improves casting quality, lowers costs and reduces rejects is described in literature available through the Carborundum Co. Bulletin Bd-57.

High Temperature Fans

A 4-page illustrated bulletin on this subject has been released by Michiana Products Corp. The applications (where temperature requirements range up to 1800° F.) are enumerated and construction described. Stock sizes mentioned include fans up to 32,000 cubic feet per minute capacity. Bulletin Hb-81.

Moly in Steel

Metallurgists, engineers and production executives who are really interested in the metallurgy of steels and their application will want the excellent book on molybdenum steels published by Climax Molybdenum Company. Bound in loose-leaf manner, this reference book is chock-full of tables which form a volume almost an inch thick. Bulletin Hb-4.

Vacuum Cleaning

A very colorful brochure which illustrates modern cleaning methods by vacuum in industrial plants has been released by The Spencer Turbine Co. Bulletin Dc-70.

No Back-Fire

A burner that cannot back-fire is described in a brand new booklet on the fuel equipment products made by the Eclipse Fuel Engineering Co. Bulletin Ad-226.

USE THE COUPON ON PAGE 186 TO OBTAIN THIS HELPFUL LITERATURE

Lectromelt Furnaces

The story behind lectromelt furnaces is well told in this 48-page booklet issued by the Pittsburgh Lectromelt Furnace Corporation. Tells of development and recent improvements. Bulletin Db-18.

Heat Treat Chart

Heat treaters everywhere should find a heat treating wall chart complete with S.A.E. specifications a very valuable addition to their shops. Published by Chicago Flexible Shaft Co., manufacturers of Stewart industrial furnaces. Bulletin Ka-49.

Pure Metals

Pure, carbide-free metals are described and applications suggested in a pamphlet published by Metal & Thermit Corp., who make pure tungsten, chromium and manganese in addition to the ferro-alloys. Bulletin Ma-64.

Specialized Tester

The Rockwell superficial hardness tester is a specialized instrument for use where the indentation into the work must be kept shallow or of small area, yet sensitivity preserved. A supplement to Wilson Mechanical Instrument Co.'s catalog on the regular Rockwell tester tells all about it. Bulletin Sy-22.

Ferro-Alloys

An interesting folder by Electro Metallurgical Co. tells all about their ferro-alloys and their special service to users which will help them to operate their furnaces and make alloy additions under the proper conditions. Bulletin Jy-16.

Char-Mo Atmosphere

A colorful folder explaining how molybdenum steel can be heat treated without decarburization is now available through the Surface Combustion Corporation. Points out advantages of the new Char-Mo furnace and explains its operation. Bulletin Lb-51.

Machining Steel

An 80-page book of general and specific information on steels, including tables of recommended cutting speeds and feeds for many grades of carbon, alloy and stainless steel, is available from the Union Drawn Steel Division of Republic Steel Corp. Bulletin Nc-8.

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Constant proportion of fuel—insuring an even heat—is maintained in gas furnaces by the North American AIR-GAS RATIOTROL.

Both air and gas are interdependent, yet the RATIOTROL is so flexible that corrections for capacities, varying pipe resistances, etc., can be made without altering the installation itself.

The control valve has an adjustable port that can be set to insure effective control of the air over the whole motor operating range together with an external by-pass to furnish air at blower pressure to an auxiliary diaphragm on the atmospheric regulator when the control motor goes to the shut-off position.

The force from this diaphragm actually closes off all gas flow to the burners at this point which among other advantages eliminates all possible over-riding of temperatures at low temperature settings.

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● ***Some of the foremost experts in the metal industry have contributed to the wealth of information contained in the literature described on this page. You will find your time well spent in looking it over. One booklet may solve your most difficult problem. Use the convenient coupon today to obtain this free literature.***

Portable Potentiometer

An extremely versatile indicating potentiometer with precise balancing, quick standardization, and easy-reading scales is described and illustrated in a folder by the Foxboro Co. Bulletin Nc-21.

Heat Treating Furnaces

A brand new 16-page booklet of Holcroft & Company shows and describes their line of controlled atmosphere heat treating furnaces. Bulletin Ec-203.

High Speed Steel

Required hardness and extraordinary toughness combine to make Firth-Sterling Co. new high speed steel "Mo-Chip" of unusual interest to manufacturers who need a steel that is "practically indestructible." Bulletin Ad-177.

Electric Furnaces

A new catalog on electric furnaces and pyrometers has been released by the Hoskins Manufacturing Company. For anyone who does any kind of heat-treating, brazing, or uses heat-resisting castings. Bulletin Hc-24.

Handy Tool

That the "tool of 1001" uses is rightly named will be admitted by anyone who looks over Chicago Wheel and Manufacturing Co.'s 63-page catalog on the "Handee". See how you can use it in your business. Bulletin Ec-230.

Fatigue Test

A complete description of the fatigue test as made on the R. R. Moore fatigue testing machine is given in a folder by Baldwin-Southwark Corp. Examples are discussed and illustrated. Bulletin Ka-67.

Pot Furnaces

The new features of American Gas Furnace Co.'s improved pot hardening furnaces include insulating refractory lining backed by block insulation, heat resisting alloy burners, single valve control, numerous small burners with their attendant advantages, burner location and method of venting. Fully described in Bulletin Sy-11.

Thermocouple Insulators

An exceedingly complete stock of thermocouple insulators is described in a bulletin made available by the Claud S. Gordon Co. Bulletin Hc-53.

Chapmanizing

Chapmanizing, the method of surface hardening steel with nitrogen, is described in a very attractive booklet of Chapman Valve Mfg. Co. Information is given on the method itself and on its metallurgical advantages. Bulletin Ob-80.

Welding Stainless

How to weld stainless steels is described in a colorful 12-page folder released by the Page Steel and Wire Division of American Chain & Cable Co., Inc. Bulletin Cc-86.

Electroplating

A complete group of chemicals, processes and materials of interest to those engaged in electroplating is listed in this 8-page booklet published by the E. I. Du Pont de Nemours & Co., Inc. Bulletin Eb-29.

Cr-Ni-Mo Steels

A. Finkl & Sons' catalog is really a technical treatise on chromium-nickel-molybdenum steels for forgings. Pocket size, 104 pages, cloth bound, illustrated by photographs, charts and tables. Bulletin La-23.

Laboratory Furnace

The Sentry Co. describes a high temperature tube combustion furnace. It permits operating temperatures up to 2500° F., thus offering greater speed and precision for combustion analysis or other laboratory procedures. Bulletin My-114.

Hydraulic Tester

Of interest to all engineers recommending or purchasing universal testing machines is a book by Riehle Division of American Machine and Metals, Inc., on the development of the precision hydraulic testing machine. Bulletin Ba-157.

Ni-Cr Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Carburizing Salt

A technical service bulletin describing a new development—Du Pont Carburizing Salt—for the economical production of deep high-carbon cases on plain carbon and alloy carburizing steels . . . available through Du Pont. Bulletin Dc-29.

Oil Burners

North American Mfg. Co. offers a bulletin describing improved low pressure oil burners, one type especially designed for automatic control and ideally suited for use with proportioning control valves. Bulletin Na-138.

Metallographic Reference

Nearly one thousand technical books and reference papers on Optical Principles in Metallography are listed in the new Metal Analyst just released by Adolph I. Buehler. Bulletin Lc-135.

Testing and Controls

An up-to-the-minute booklet on foundry sand testing and control equipment is just off the press. Published by Harry W. Dietert Co. Bulletin Ec-198.

General Data Book

Valuable reference and data are contained in a book by Joseph T. Ryerson & Son, Inc., which gives metallurgical definitions, heat, hardness, and numerical equivalent tables as well as many valuable operating facts. Bulletin Nc-106.

Metal Progress, 7016 Euclid Avenue, Cleveland, O.

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Bd-170	Hb-4	Sy-22	Hc-24	Cc-86	Dc-29
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Preferred POSITION

News from Metallurgical Headquarters

FEBRUARY 1940

MARKET-CONDITIONING

Educating 12,000 Men to Use of Better Metals, Methods, Machinery

Each year about this time, the 50 local chapters of the American Society for Metals — from Montreal and Boston to Portland and San Francisco and all important industrial points in between — begin work on educational programs for the year 1940-41.

These fifty chapters, through their program committees, work out a complete series of monthly lectures on the phases of metallurgy in which each group is most interested. Experts in every branch of the metal producing and working industries are lined up to present last-minute developments on methods and equipment.

These monthly lectures before these 50 chapters attract an average audience of 100 men at each meeting. In other words, some 5,000 men gather each month — at the rate of 60,000 a year — to hear these lectures. This shows the keen insight with which each local program committee measures the interest of members in various metallurgical subjects.

It also shows how educates industry to a better production, fabrication and use of metals — how it conditions and creates new markets.

It shows that whether or not the advertiser selling these industries uses the Society's monthly magazine, *Metal Progress* — he benefits from this powerful force for progress.

It is important, too, to note that the outstanding lectures presented before these local chapters become the basis for a practical, how-to-do-it article in *Metal Progress*. This is just one more check on the reading interests of the 12,000 men who make their metallurgical headquarters, and *Metal Progress* their monthly magazine.

25th Anniversary (Advt.)

Many manufacturers have already made their plans to unite with members in observing the Society's 25th Anniversary in the March issue of *Metal Progress*. If you have not made your reservation for space in this issue, do it today.

FEBRUARY GALLEYS

Cans and Cold Waves

The recent cold wave that swept into the deep South menacing multi-million-dollar fruit and vegetable crops has a direct effect on the steel industry, Bruce W. Gonser, Metallurgist at Battelle Memorial Institute, points out in the February issue of *Metal Progress*. Writing on tin plate in the canning industry, Mr. Gonser states that $2\frac{1}{2}$ million tons of low carbon, annealed sheet steel go into cans and any blight that reduces the demand for tin cans is felt by the steel industry.

Superfine Metals

An editorial comment in "Critical Points" shows that metallurgical headquarters have definitely been transferred from the Old World to these United States. This lies in the fact that superfine raw materials enable Pratt & Whitney to guarantee their airplane engines for much longer continuous operation than that of a good French or German engine.

Gill Biog.

One of the highlights of the February issue is the biography of President James P. Gill, Chief Metallurgist at Vanadium-Alloys Steel Co. Mr. Gill, incidentally, has been packing them in at recent chapter meetings with his lecture on "Recent Developments in Tool Steels". At Chicago recently nearly 300 men jammed the ballroom of the Medinah Club—a real compliment to Mr. Gill and a real interest in tool steels.

Miscellany

Other articles that will feature the February issue include an editorial first—the discussion of a new "union of metals" called "Pluramelt" by Allegheny Ludlum Steel Co. . . . "Zinc Die Casting", by R. L. Wilcox of New Jersey Zinc Co. . . . "Machining of Cast and Wrought Aluminum Alloys", by Walter A. Dean, of the Aluminum Co. of America.

NO RATE UPPING

Net paid circulation for *Metal Progress* has zoomed upwards along with the industrial tempo, and the December Publisher's Statement to be filed with A.B.C. will show an audience of 11,712. This is an increase of 1,206 net paid readers—and the trend is still up!

This is the big circulation in the field but publisher's policy will be to retain present low base rates of only $100 per page—an advertising buy that is hard to match. That advertisers recognize this is shown by the January issue—carrying the largest advertising volume of any January issue.

PREPARED BY METAL PROGRESS, THE AMERICAN SOCIETY FOR METALS MAGAZINE
7301 EUCLID AVENUE *A.S.M. is Metallurgical Headquarters* **CLEVELAND, OHIO**

Contributors in This Issue

Vere B. Browne came to Allegheny Steel Co., Brackenridge, Pa., in 1909 to serve as chief chemist. His rise to vice-president and director of the now Allegheny Ludlum Steel Corp. was steady. In 1912 he was promoted to technical superintendent of the openhearth; to assistant general superintendent in 1914. Following appointment to general managership, he became assistant to the president in 1923, vice-president in charge of research in 1930, and director in 1936.

Harry S. Blumberg, junior author of the article on steels of plural composition (page 163) held several positions in the 11 years before he settled down as metallurgist for M. W. Kellogg Co. in 1926. He was chemist with Illinois Tool Works, metallurgist for Illinois Steel Co. and A. O. Smith Corp., Milwaukee. Mr. Blumberg's forte is pressure vessels and their welding, and he is co-author of chapters in both the ⊕ Metals Handbook and the Welding Handbook. He served as secretary of the Chicago Chapter 1920-22, and is now on the executive committee, New York Chapter ⊕.

C. A. Liedholm received a scholarship from Jernkontoret (Swedish Iron Masters' Association) in 1928 for the study of electric steel melting in the United States and has been here ever since. He is now with Jessop Steel Co., as metallurgical engineer in charge of physical and metallographical laboratory and research. Prior to coming to this country he was chemist for DeLaval Separator Co. in Stockholm and assistant metallurgist for the Hellefors Co. In January 1939 METAL PROGRESS he discussed the problem of the influence of oxygen in steel on its weldability.

Graduated in metallurgical engineering from Pennsylvania State College in 1930, **Ralph L. Wilcox** joined the research staff of the New Jersey Zinc Co. Here he cooperated in original researches on zinc alloys and is co-author of several publications in this field. Transferring to the sales organization in 1937, he was assigned to the Detroit office, and naturally finds one of his biggest fields in the applications of zinc die castings to automobiles, which he discusses in detail in the article starting on page 150.

Bruce W. Gonser's first position as metallurgical engineer in the research department of American Smelting and Refining Co. in 1924 took him during the next eight years to many of the company's plants and familiarized him with various hydrometallurgical and volatilization processes, the electrodeposition of zinc, antimony, lead, and copper. He joined Battelle Memorial Institute in 1934, where his position is supervisor of research in nonferrous metallurgy. Gonser graduated from Purdue as a chemical engineer in 1923 and was awarded a master's degree in chemical engineering in 1930. Graduate work at Harvard brought him a D.Sc. in 1933.

Another non-ferrous expert is **Dana W. Smith,** who has been in the metallurgical division of the Aluminum Research Laboratories at New Kensington, Pa. since 1934. With a B.S. from Missouri School of Mines and Metallurgy in 1929, he went to Yale and emerged with a Ph.D. in 1932. During the intervening two years (before going to Alcoa) he was associated with the Metals Research Laboratory of Carnegie Institute of Technology.

Harry S. Blumberg

Bruce W. Gonser

Ralph L. Wilcox

Dana W. Smith

Tin Cans

(Continued from page 141) containers and with stainless steel, but so far they have been unable to compete with a No. 2 can costing less than 2¢. Aluminum coated steel is a commercial product and has been tested by some can manufacturers without entirely satisfactory results; it may eventually be used. The saving in the cost of tin by using aluminum, a cheaper metal, is comparatively small and partly counterbalanced by a more expensive method of manufacture. Much work has also been done recently on very thin electroplated silver coatings, but this, if successful commercially, probably will be confined to containers of foods or beverages that command a high retail price. Electrodeposited nickel and composite nickel with tin or chromium coatings have attracted the attention of can makers and considerable interest is shown in testing them.

Other developments in can making which are scarcely in the commercial stage include deep drawn or seamless can bodies having only one end to be seamed after packing. The severe drawing operation destroys much of the value of the tin coating, hence an effective lining enamel must be applied after forming the can body. There are possibilities, too, in depending entirely on an organic lining material over a bare steel container. Welded cans are a possible future development of importance.

In the meantime the manufacture of tin plate is due for some improvements. With the advent of cold reduced steel strip in lengths of 5000 ft., or even more, there is a strong urge to tin these coils in a continuous process. Continuous hot tinning of cold rolled steel strip and its use by the can manufacturer in this form is by no means distant. Narrow strip 8 to 12 in. wide has been produced but not used for making packers' cans. Difficulties from "dry streaks" when tinning wider strip do not appear entirely insurmountable.

At present the continuous electro-tinning of steel strip is in limited commercial production and may soon be utilized more extensively for containers for the food industry. At present such material is largely used for can ends and for certain dry containers like coffee cans. The tin coating of electro-tinned plate is likely to be between 0.5 and 1.0 lb. per base box for use by canners. Economies in the continuous production of tinned strip and use of somewhat less tin, and in the elimination of dross losses when hot tinning, help compensate for some of the higher initial costs of the electrotining process.